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Halbert P. Gillette, *President and Editor*

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THE SEASON OF NEW RESOLUTIONS.

Although New Year's resolutions have become the butt of every newspaper "paragrapher" and of merry jesters in general, isn't it a good thing that we have at least one customary time each year for taking inventory of our past performance and for scheduling our future actions? Failure to live completely up to a schedule is hardly good reason for abandoning all systematic planning of events. Rather does the failure to keep a resolution serve to emphasize the need of continuing to resolve once again to adhere to those modes and times of action that one's better judgment has sanctioned.

Because many trains arrive late, or some not at all, is not used as a reason for abandoning the use of time tables. And what are time tables but predetermined resolutions that such and such things shall happen as planned? If we get into the habit of regarding New Year's resolutions as we regard time tables—definite plans for definite actions—we shall give them less laughter and more sober consideration.

Each individual should now make new resolutions, or renew old ones, or both, with particular reference to his own personal requirements, but of these it is not our province to speak. In addition, each class of men should resolve to work more effectively in the interest of his class associates—engineers in aid of engineers, contractors in aid of contractors. There is both a higher selfishness in such altruism and a higher altruism in such selfishness; for if a class of "producers" becomes more effective as a class, not only will the individual members of the class benefit, but all society will share the gain.

The engineer who designs or supervises, and the contractor who manages construction are equally to be classed as "producers."' Every man who promotes the welfare and happiness of mankind is a producer, whether he works with his head or hands. Indeed, judged by the output resulting from his brainwork, Blake, the inventor of the rock crusher, was a greater producer than all the hosts of hammer-wielders who had preceded him. In his "Progress and Poverty" Henry George was wrong more often than right, but he was eternally right in his theory that every man who increases the output of other men, whether by engineering, inventing, or teaching school, is a true producer.

Let us individually and collectively take stock of the past year's achievements, and resolve not only vaguely but with definite plan to bring 1917 to a better finish than 1916.

WANTED, A CITY MANAGER AT $5,000 A YEAR.

When a small city, which few of us ever heard of before, announces that it wants a city manager at a five thousand dollar salary, we see indeed a political swallow that harbingers a welcome spring. Yet, if news reports are trustworthy, Marysville, Cal., is such a city.

We were not so greatly surprised when Springfield, Ohio, recently robbed Staunton, Va., of its justly celebrated manager, Charles E. Ashburner, C. E., for he is a pioneer of his class and has "made good with both feet"—and his head. Mr. Ashburner now receives $6,000 a year at Springfield, yet we venture the prediction that within a few years he will be a city manager at double his present salary. Why? Look at his record, and at the same time remember that American cities have entered on an entirely new era—the era of the engineer as an executive public officer.

Three years ago Mr. Ashburner was selected as manager of Springfield by a board of five City Commissioners who had been chosen by vote. These commissioners correspond to the directors of a stock company, and their most important function was to select an executive head for the city. When Mr. Ashburner took charge he inherited a municipal floating debt of $125,000. Taxes were 1.5 per cent. He has wiped out the floating debt and lowered the tax rate to 1.3 per cent. But this has not been done at the expense of city upkeep or improvement. On the contrary, new paving has increased one-third, for example. Fire hose that formerly cost $1 a foot was bought for 53 ct. Out of such savings and by exacting a full day's work from every employe, the money has been found with which to make Springfield a better and a cheaper city to live in.

To civil engineers who have been sitting around whining about inadequate public appreciation of engineers, such achievements as this should be both an admonition to shut up and an inspiration to get up. The public is only waiting for such leadership as this engineer, Mr. Ashburner, has given them, before it will respond with greater rewards both of position and emolument. Let engineers act individually and collectively this year, and it is not too much to predict that within two years five times the present number of 100 cities under the "commission plan" will have decided to abandon the antequated form of "representative government."

What is more, although only a few thousand engineers can hope for places as city managers, the effect of raising many engineers to executive positions will inevitably be the raising of the average income of all engineers employed by the public. As we have repeatedly said in these columns during the past decade, the most certain and effective method of increasing the average pay of engineers is through the placing of engineers in executive charge of public and private enterprises.

DIFFERENT MOVEMENTS TOWARD FEDERATION OF LOCAL ENGINEERING SOCIETIES.

Seattle is one of several cities where engineers have begun to co-operate in a broad way. An Association of Engineering Societies was organized Dec. 9 in Seattle. The federation includes the Puget Sound members of four national societies, namely, American Society of Civil Engineers, American Institute of Electrical Engineers, American Institute of Mining Engineers, and American Chemical Society. It also includes the Pacific Northwestern Society of Engineers and the Washington Association of Engineers.

This new association will hold periodic meetings not only for the purpose of listening to and discussing technical papers, but to consider public problems in which engineers should endeavor to guide public opinion. A library will be gathered, and other steps taken to bring all engineers into fraternal co-operation for mutual advancement.

In the South the Affiliated Technical Societies of Atlanta was organized three years ago. It is made up of the local sections of five national societies and the Engineering Association of the South. It has recently indicated its determination to participate in the solution of civic affairs.

The Minnesota Joint Engineering Board consists of members of local sections of three national engineering societies, three local associations and the Engineering School of the University of Minnesota. Its purpose is to "take a hand" in federal, state and municipal legislation.

Eleven years ago, when Engineering and Contracting was founded, its editor began preachment of the idea that engineers should organize with a view to influencing legislation, as well as for the purpose of educating the public to the desirability of employing engineers as executive heads of many public service departments and bureaus. Both in editorials and in addresses to local engineering societies and clubs, this idea—then new—was given publicity. Now that the idea has attained such momentum that it can not be stopped, it affords us no small measure of satisfaction to recall our part in the furtherance of the plan to federate engineering societies for the purpose of concerted action in public affairs.

THE DESIRABILITY OF STATE LAWS LICENSING ENGINEERS.

Civil engineers in Texas are planning to secure a state law licensing engineers to practice in that state. While the similarity of a license to a "closed shop" has led many engineers to rebel at license laws, there is, we believe, a growing disposition to regard this sort of legislation with favor. Altogether too many engineering positions are held by men whose right to the title of engineer is, to say the least, dubious. Since the public cannot readily discriminate between a technically untrained man and a technically trained man, the engineering profession is often brought into ill repute by self-styled engineers in public office.

Perhaps the two commonest arguments in favor of a state law licensing engineers are: First, that public safety requires that none but trained engineers be allowed to design bridges and other structures whose failure would imperil life. Second, that deception may not be practiced by men who pose as engineers but are not. Why not add to these two common reasons a third that is less common but quite as important? The great function of engineering is to apply science in solving the problems of economic production. A law licensing engineers would not only reduce deception and increase safety, but it would serve to elevate the status of applied science in the public mind. Furthermore, it would serve to give a needed distinction to the class of men who have given their time to the study and practice of science for the purpose of increasing the efficiency of men and their tools.

Even among some engineers there persists a narrow view of what engineering is and what it aims to accomplish. Not until engineers are forced to define their own profession broadly, and to live up to the definition, is it likely that the public will itself come to regard the civil engineer as being much different from the locomotive "engineer." So, not merely to prevent masquerading, but to clarify the public conception of this great profession, does it seem desirable to secure the passage of laws licensing civil engineers.

The Canadian Society of Civil Engineers has already shown us the way, and we may well study what they have accomplished. The engineers of Illinois have secured a law licensing structural engineers, thus giving them an equal footing with architects. Architects, by the way, have long regarded their license laws with favor. It can scarcely be that they have been so obsessed by an idea as not to see its serious defects, if any there were.

Perhaps most laws licensing trades and professions have sprung from a selfish purpose—the restriction of competition. Doubtless it is this fact, more than any other, that has made engineers averse to fostering a law licensing engineers. But if it can be shown—and we regard it as self-evident—that an engineers' license law is primarily desirable because it will elevate the engineering profession in the eyes of the public, then most of the opposition to such laws will vanish.

Doctors are licensed in the interest of public health, architects in the interest of public safety. Let engineers be licensed in the interest of public economy, for economy is primarily the function of engineering. At the annual banquet of the Washington Society of Engineers, Dec. 5, Newton D. Baker, Secretary of War, scattered many verbal roses in the path of engineers. He said: "The engineer is going to take his place alongside of the politician in making possible the vast extension of activity in our country."

Yes, and the civil engineer is going to be the politician—the true political economist; for political economics is, after all, merely industrial economics on a broad scale, and what is the engineer if not a technically trained economist?

COST OF ENGINEERING AND OTHER ITEMS ON CALIFORNIA ROADS.

In an expenditure of about $16,500,000 for state roads in California, engineering and allied overhead costs have been 12.75 per cent of the gross construction costs of those roads that have been completed. This relates to 1,490 miles, of which 966 miles are concrete ("oil-surfaced"), 129 miles are oiled macadam, and 395 miles are graded but not paved.

A total of 2,350 miles have been surveyed, including the 1,490 miles built, and the surveying has cost $317 per mile.

The 1,490 miles of completed roads (395 miles not paved) have cost about $11,000 per mile, so that the surveying alone has averaged nearly 3 per cent of the construction cost. This leaves about 9.75 per cent as the cost of engineering inspection, laboratory testing, equipment depreciation, legal expense and expense incident to purchasing cement and asphaltic oil for the roads. The legal expense (less than $30,000) and the laboratory testing (less than $28,000) have been very small. It would be interesting to know the purchasing expense, distinct from engineering and inspection.

Nearly all the work has been done by contract, the state furnishing the cement and asphaltic oil.

The state has purchased equipment (autos, camps, furniture, etc.) costing about $165,000, having a present salvage value of about $107,000. The depreciation of $58,000 is included in the 12.75 per cent above given. Hence, if we deduct surveying, legal expense, laboratory testing and equipment depreciation, we have left about 9 per cent as the cost of engineering, inspection and purchasing.

Average unit costs of this construction work (including materials) during the past six years have been about as follows: Excavation and compacting subgrade, 41 ct. per cu. yd.; concrete pavement (including cement), 4 in. thick, 74 ct. per sq. yd.; asphalt wearing surface (1½ in. thick), 45 ct. per sq. yd.; oil top (⅜ in. thick), 5.4 ct. per sq. yd.

These are all low costs, so low in fact that very few contractors made any profit. An average excavation price of 41 ct. per cubic yard in a country where wages of common laborers were $2.50 a day, is well below the average actual cost of road grading work where the grading includes shaping, finishing, watering and rolling the subgrade with a gasoline or steam roller. But each season brought its new crop of ignorant bidders, and even the better informed contractors underestimated the cost of the work.

This we know, not from the reports of the Highway Commission or its engineers, but from personal interviews with a great many of the contractors.

We are inclined to believe that, at "living prices," the 1,490 miles already built would have cost fully 25 per cent more than they did cost, and that in consequence the state of California is several million dollars richer than it would have been had all the contractors been fully acquainted with the actual cost of road work.

LIFE OF ROAD CONSTRUCTION EQUIPMENT.

In estimating the cost of roadwork the useful life of the construction equipment is often underestimated. It will interest highway engineers and contractors to know that the Arizona Highway Department has adopted an equipment depreciation table to be used in cost estimating. The table is as follows:

	Annual depreciation, per cent.
Steam shovels	10
Engines, gas or steam	20
Concrete mixers	20
Rock crushers	20
Pile drivers	20
Graders	20
Plows	20
Wagons and harness	20
Mules	10
Wheelbarrows	50
Concrete carts	50
Fresno scrapers	100
Tents	75

With the exception of mules, the life of the equipment is not solely dependent on the lapse of time. The length of the road building season, the continuity of the work and the care given in handling and maintenance, are all important factors in determining the life.

As for tents, it is not unusual to have them whipped to ribbons by strong winds in three months or less. On the other hand, if used only in dry weather, and where winds are not high, a tent may last several road building seasons.

In this connection it seems wise to point out that annual depreciation rates, such as those above given, are often assumed to include current repair costs, although usually the depreciation rate is intended to relate solely to the loss of life of the entire machine and not to loss of life of its parts. Railway locomotives, for example, have had an average life of about 25 years, or a straight-line depreciation rate of 4 per cent per year, assuming no scrap value. But the current repairs on railway locomotives have averaged about 18 or 20 per cent per annum.

Apparently the rates of annual depreciation above given do not include current repairs. Yet, if not, why is the annual depreciation of a steam engine put as high as 20 per cent? A steam engine will surely last as long as a steam shovel, yet the latter is given a depreciation rate of 10 per cent.

The fact is that not a great deal has been published on the lives and maintenance costs of construction equipment. Dana's "Handbook of Construction Plant" gives data on this subject. The startling fact is brought out there that for one year (1908) repairs on steam shovels on the Panama Canal amounted to nearly 50 per cent of their first cost! This was equivalent to nearly 3 ct. per cubic yard excavated. This, of course, was under unusually expensive conditions and where the work was continuous. Dana puts the average life of a steam shovel at 20 years.

In calculating depreciation and repairs, it is usually desirable to separate the two. Estimate depreciation for the full years, but estimate repairs by the month of actual work. Thus, in the case of a steam shovel, the annual depreciation may be estimated at 6 per cent, and the repairs may be estimated at 2 per cent per month of single-shift work. Then if it is estimated that the shovel will actually work six months during a year, the depreciation amounts to 1 per cent and the repairs 2 per cent per month of actual work.

Roadbuilding equipment averages less than 6 months' actual work in the northern states—probably about 4 months. This runs up the interest and depreciation charges per month of actual work. Thus, with annual interest at 6 per cent and depreciation at 12 per cent, we have 18 per cent for the year, or 4.5 per cent per working month if charged entirely against the working time. Add to this, say, 2.5 per cent for repairs, and we have a total of 7 per cent per working month for interest, depreciation and repairs.

Many a road building contractor has "gone broke," and many a highway engineer has erred grievously in his cost estimates, through failure to estimate correctly fixed charges and repairs on road building equipment. Add to this sort of underestimate one or two others of similar nature, and we have an almost complete explanation of why a new crop of road-building contractors buds forth each spring only to wither permanently each autumn.

THE TENDENCY TOWARD USE OF MORE CEMENT AND GREATER THICKNESS IN CONCRETE ROADS.

Up to about two years ago, concrete roads built by the New York State Highway Department were made of 1:2.5:5 and 1:3:6 mixes. Now the standard mix is 1:1.5:3. Of this rich mixture about 200 miles have been finished and 300 miles are under contract.

Many of the New York concrete roads of 1:3:6 mixture have failed to withstand heavy traffic, when directly exposed to the impact of wheels.

Since the present rich mixture of 1:1.5:3 requires about three-quarters of a barrel more cement per cubic yard than the old lean mixture of 1:3:6, it is obvious that the highway engineer should seriously consider the advisability of returning to the older practice of building concrete pavements in two layers. This is particularly emphasized by another fact, namely that the tendency is toward the use of thicker concrete pavements. Increasing wheel loads make it necessary either to make a much better subgrade or to thicken the concrete, or both.

May it not prove advisable in many cases to build a waterbound macadam or gravel base beneath the concrete? Certainly where a macadam or gravel road already exists it should not ordinarily be ripped up merely because concrete or some other type of pavement is to be laid.

If the pavement is to be entirely of concrete, and 8 in. or more in thickness, there is little doubt in our minds that it should be built in two layers. The base layer should be lean in cement, even to such a leanness as, say, 1:4:8. The top layer should be rich, say 1:1.5:3, and not more than 3 or 4 in. thick. Should the two layers be separated by tar-paper or otherwise? We think so, for it is beyond experience with any type of pavement to find it unnecessary ever to repair the wearing surface.

Much foolish hope about concrete roads has been published in such form as to give it the semblance of demonstrated fact. It has been so repeatedly stated that concrete roads are everlasting that not a few engineers who should know better have come to believe in the assertion. "Everlasting" is quite a long-time word to apply to a short-time experience, and certainly experience with concrete roads can not be claimed to be very long. Also where experience has been longest we do not find any evidence that concrete is as durable as brick, or asphalt, or creosoted wood block, under fairly heavy traffic.

Steel rails are not everlasting. Why, then, do engineers expect a much less tenacious material to hold up forever under heavy traffic? And if concrete will not last indefinitely, why build it so that it can not be readily repaired except at the cost of removing the entire thickness of the pavement?

EDITORIAL COMMENT.

Commissioner Fetherston of the New York City Department of Street Clearing, was the object of considerable ridicule when he introduced "efficiency engineering" two years ago. The New York dailies are now beginning to praise him for his prompt and effective handling of the snow. Thus once more does an engineer justify the growing public confidence in engineers as administrators of municipal affairs.

In 1910 the California vote for the $18,000,000 state bonds for roads carried by a bare majority. The recent vote for $15,000,000 additional bonds for roads overwhelmingly—2 to 1—endorsed the California Highway Commission's administration and voiced demand for more of the same brand of highways and highway management.

In Dallas, Texas, about two-thirds of the engineers in the employ of the city have formed an engineering library club. Desirable books for the library are suggested by members, and a vote is taken upon the suggestions. This, however, is one of many instances where the majority should not rule; for it often happens that the majority knows very little about a particular book.

In Chicago the Association of Commerce has an engineers' subdivision, and one of its committees is now considering ways and means by which to educate the public to the economic necessity of reducing the great waste of city water. This is one of the most commendable, and at the same time most practical, steps taken by engineers in the interest of municipal welfare that has come to our attention. Query: Why do not engineers in every city join the Chamber of Commerce, and form an organized subdivision thereof?

Horses' calks, especially the long, sharp kind worn in winter, used to be very destructive of macadam roads. In their place have come tire-chains, which often leave their marks on concrete as well as macadam. Let it not be assumed, therefore, that rubber tires have reduced the difficulty of maintaining even monolithic paved surfaces.

SUGGESTIONS AS TO THE CAUSE OF CRACKS IN CONCRETE ROADS AND CONCRETE BASES.

To the Editor: After making numerous inquiries among road officials and others, and making a careful study and examination of existing concrete pavements and bases in localities within a wide range of latitude, I have come to the conclusion that very radical departure from the methods now in vogue must be made in both the design and construction of concrete pavements and concrete bases for other type pavements if resultant cracking is to be reduced to a minimum.

Probably in no line of concrete construction has the number of failures been greater than in pavements. Not only does this statement apply to typical concrete pavements, but also to other forms of pavements built upon a concrete base. Many failures of these latter types may be traced to faulty foundations and interior deterioration. Certain existing successes, however, proclaim that good results may be secured. Concrete is comparatively new in its extended use as a pavement and existing information relative to maintenance costs is of a very tentative nature. We must, therefore, view the subject and base our conclusions upon the fundamental principles involved in the design of other structures using concrete as a structural material. In this connection the writer feels free to state that these principles have heretofore been frequently ignored. I have endeavored to take up the various steps in their relative order and to point out defects and suggestions as to their remedies.

Design.

The primary cause of failure is due to neglect in investigating the problems involving the forces acting upon concrete slabs laid upon earth and subjected to stresses incident to the heavy impact of motor trucks and other severe concentrated loads, the expansion and contraction due to heat and cold and the stresses set up by the increased internal temperatures of the mass while setting; the rise and fall of the earth surface due to climatic changes also exert a very detrimental effect on concrete slabs. Of course it is admitted that all of these forces cannot be ascertained with precision, yet they should be computed as nearly as possible and considered as acting on the slab when designing the section. The present sections, in many cases, indicate that these forces are given not even the slightest consideration.

It is a very common sight to see large and deep cracks in the natural ground due to horizontal shrinkage. The fact that earth swells as a result of absorption of moisture is equally proved. The movements thereby caused would be of sufficient force to disturb the slab and, unless the slab is of proper thickness and strength, failure is bound to occur. As may be naturally expected, the earth subgrade will, under the action of traffic, be more compacted at the center than at the shoulders, whether the slab be placed on a fill or in excavation. This condition is brought about not only by subsequent traffic, but by the ordinary methods of subgrade construction.

Cantilever action will take place with resulting cracks, due to bending moments induced by upward pressure near the shoulders or by settlement of the subsoil at this point. Consequently, longitudinal cracks are bound to develop unless the slab be designed to resist bending. A slab designed under consideration of the above forces would necessarily be heavy and costly when considering widths of roadway such as are now in use. Therefore, our only solution is to construct pavement slabs with longitudinal joints, thereby reducing the width of the slab; the number and location of these joints depending, of course, on the width of roadway.

The reliability of concrete under compression is established beyond a doubt. However, its ability to resist tensile stresses should be entirely ignored, as is done in the case of all other properly designed concrete structures. Strange to say, however, in pavement construction concrete is depended upon or at least subjected to tensile stresses far in excess of its ultimate breaking strength. Stresses induced during setting and subsequent contraction due to changes of temperature and reactions caused by movements of the subsoil cause the slab to slide on the foundation, thereby generating tensile forces, with resulting rupture of the slab transversely and also diagonally where occurring in connection with cross-bending moments. These stresses are provided for in other forms of concrete construction where direct and diagonal tension are involved, and certainly should be provided for in pavements, which are of necessity subjected to much greater abuse than other forms of structures.

These facts would indicate that carefully constructed transverse joints should also be provided, thereby forming with the longitudinal joints a series of square or nearly square panels. These joints must of course be very carefully designed and so constructed as to minimize abrasion and spalling and must wear evenly with the pavement. We would not think of constructing a reservoir floor monolithically, yet these floors are covered by a certain depth of water which minimizes the effects of climatic changes, the subterranean movements acting, of course, as in the case of pavements. Time spent in an effort to derive an empirical formula for the determination of the proper thickness of slab for various size panels, soil and traffic conditions, and the design of a suitable and evenly wearing joint will prove profitable.

Construction.

As in all road construction, too much emphasis cannot be placed on the necessity of adequate drainage provisions. Great care must be exercised in compacting the foundation uniformly over the entire width so as to avoid as much vertical movement as possible, and the entire subgrade should be thoroughly but lightly sprinkled immediately before placing concrete. The selection of materials and the mixing and placing of the aggregate should receive the same thorough and competent inspection as is necessary in other forms of concrete construction. It is also very apparent that the pavements as well as bases should be constructed with a horizontal base and the crown made up in the concrete. Another important point is the proper care and protection of the concrete when first laid.

One of the most frequent causes of transverse cracks is the shrinkage of the concrete when curing without a proper supply of moisture. The writer has observed section after section of concrete base and pavement laid in the dry season and not receive a drop of water after the material was placed. Experience and tests have proved that a shrinkage during setting of from ½ to 1 in. per 100 ft. may be expected with ordinary mixtures, which would be equivalent to a fall in temperature of 110° F.

The concrete should be kept constantly wet during the first 6 or 7 days after placing and should not be subjected to traffic for at least 30 days. No disturbance of the wearing surface should be allowed after the initial set. All brooming and grooving should be prohibited, as it injures the texture and increases the tendency to ravel. Other details, such as one or two-course construction, are matters for discussion, although the writer is of the opinon that a two-course pavement can be constructed that will compare favorably with the more costly one-course construction. I also believe that a light wire mesh placed an inch or so below the wearing surface to prevent hair cracks from localizing would be advisable.

In conclusion will say that the above suggestions are offered not as a final solution of the details involved in the design and construction, but with the hope that they will stimulate further discussion and hasten the improvement of our present sections and specifications covering their construction. The writer is aware that in isolated cases certain of the principles mentioned have been considered, but the object sought should be a universal revision of our present standards.

Howard W. Holmes,
Designing and Consulting Engineer, Northwestern Bank Bldg., Portland, Ore.

THE LOS ANGELES STANDARD OF MEASUREMENT FOR STREET CLEANING.

The Efficiency Department of the city of Los Angeles, Cal., has recently taken the following interesting step in the direction of a generally applicable standard of measurement for the work of street cleaning:

On each route a section of street was selected for use in determining the percentage of dust removed by flushing. The section selected was 50 ft. long and free from visible litter. Its width was the width of the street (or that part of the street which was flushed), less a gutter strip at each curb. The gutter strips were excluded from the test area because of the deposits that might occur in them from the flushing of other sections of the street, and because usually they would not be dry in time for a proper completion of the test. The test area was divided into five equal sections, each 10 ft. wide. Assume them as numbered consecutively, 1 to 5. Sections 1 and 5 were cleaned very carefully before flushing as late in the evening as was possible, to avoid interference from traffic and to approximate as closely as possible the street condition at the time of flushing. Soft, fine-haired push brooms were used. The sweeeping was carefully and thoroughly done and the cleanings were collected and so marked as to identify the section of their origin.

Early the following morning, after the street had been flushed and had dried out, and before the regular hand sweeper and the full flow of traffic had come on, Section 3 was cleaned in the same manner. Sections 2 and 4 were not used except to provide areas contiguous to Section 3, which would correspond to the rest of the street.

The materials collected were carefully weighed and screened. The average of the collections from Sections 1 and 5 was used as closely approximating the weight and composition of dirt on Section 3 before flushing. The weight and composition of dirt on Section 3 after flushing was obtained by direct experiment.

DETAILED COST OF SURFACING HIGHWAY WITH CALICHE.

During 1915 a 3.06-mile section of the Phoenix-Tempe Highway, extending from the city limits of Phoenix, Ariz., to the Grand Canal, was rebuilt, the work being in charge of B. M. French, Assistant Engineer of the Arizona State Highway Department. Of the total mileage, 2.164 miles was built of caliche conglomerate and 0.9 miles of decomposed granite and caliche. The metal surface was 18 ft. wide. On each side of it there were 3-ft. dirt shoulders.

The conglomerate was quarried and crushed to 1½ in. in diameter at Tempe and hauled an average distance of 5 miles. It contained about 75 per cent of rock and about 25 per cent of caliche. The decomposed granite and caliche came from the county pit, was not crushed and was hauled an average distance of 2½ miles.

Broken Stone in Place.

The alignment of road was practically unchanged, the old roadbed being used, and the grade changed only at bridge approaches and culvert crossings. No stakes were set for the work, the grading all being done by eye.

In preparing subgrade, the old road was first scarified the full depth of the old material and where pot holes occurred to bottom of elevation of hole. It was then harrowed and a 7-ton horse roller run over it to assist in breaking up lumps, after which a 4-horse King grader was used to level it and shove enough of old road material to outer edge of 18-ft. width to assist in building shoulders for holding new material in place.

Rolling Caliche Surfacing.

The road was harrowed again and thoroughly wet to a depth of all loose material and rolled, first with a 7-ton horse roller, then with a 20-ton steam roller.

The conglomerate was dumped in windrows and spread by hand in one course. It was first thoroughly harrowed to obtain homogenous mixture, then wet, but not enough water put on to soften subgrade, and rolled with a 20-ton steam roller until well compact. It was then allowed to stand for a day or two until partly set up, and again wet and rolled, rolling and sprinkling at the same time until material puddled, the water the second time not penetrating to subgrade; 4 in. of new material was used.

After rolling the second time, borrow pits were scarified and leveled with grader, enough new material being shoved up to fill out shoulders to 3-ft. width. Shoulders were then struck off with a grader and rolled with a 7-ton horse roller.

The caliche and decomposed granite was laid in the same manner as caliche conglomerate, but was only wet once and allowed to stand until surface dried out to keep from sticking, and then rolled with a 20-ton roller until smooth. An average depth of 4 in. of new material was used.

Water was pumped from irrigation ditches directly onto road, using a 4-HP. gas engine and 2½-in. centrifugal pump with 1½-in. discharge and a 200-ft. hose. Care must be exercised in the wetting of material, when first wetting, not to allow water to penetrate subgrade and in second only enough must be used to puddle, too much washing binder away and too little allowing it to stick. The detailed cost of the work, according to the annual report of Lamar Cobb, State Engineer, was as follows:

SUMMARY.

3.064 Miles (32,360 Sq. Yd.).

	Per mile.	Per sq. yd.
Grading and scarifying	$ 428	$0.0403
Surfacing	1,760	.1666
Rolling, sprinkling	487	.0461
Miscellaneous	143	....
Total	$2,818	

GRADING 3.064 MILES, 32,360 SQ. YD.

	Total.	Per mile.	Per sq. yd.
Labor	$297	$97	$0.0092
Foreman	69	22	.0021
Team hire	341	111	.0109
Equip. rent	12	4	.0003
Superintendent	62	20	.0019
Equipment	35	11	.....
	$817	$266	$0.0244

SCARIFYING 3.064 MILES, 32,360 SQ. YD.

	Total.	Per mile.	Per sq. yd.
Labor	$118	$38	$0.0038
Foreman	26	8	.0008
Superintendent	24	8	.0009
Team hire	32	11	.0018
Equip. rent	22	7	.0006
Roller rent	136	45	.0042
Fuel (coal)	108	35	.0036
Miscellaneous expense	13	4	.0036
Equipment	15	5	.0001
	$194	$191	$0.0159

SURFACING.

Crushing Caliche, 2,496.89 cu. yd.:	Total.	Per cu. yd.
Labor	$227	$0.0915
Foreman	60	.0236
Superintendent	48	.0190
Material		
Gas, $2.68; Dist., $42.61	45	.0181
Engine oil, $5.55; cup grease, $1.85; cylinder oil, $6.75	14	.0055
Misc. 25 cells, $2	2	.0008
Equipment	32	.0126
	$428	$0.1711

Drilling and Shooting, 419 Ft:	Total.	Per ft.
Labor	$78	$0.1842
Foreman	20	.0486
Superintendent	16	.0387
Equipment	5	.0020
Black powder, $147; Hercules powder, $49; fuse, $3; caps, $2	202	.0808
	$321	$0.1289

Fresno Hauling to Crusher	Total	Per cu. yd.
Labor	$252	$0.1008
Foreman	64	.0256
Superintendent	62	.0249
Team hire	227	.0911
Equipment	39	.0156
	$644	$0.2580

Breaking Caliche:	Total	Per cu. yd.
Labor	$60	....
Foreman	16	....
Superintendent	12	
Labor, foreman, superintendent		$0.0346
	$88	$0.0346

WORK AT COUNTY PIT.

Drilling and Shooting 933.42 cu. yd.:	Total.	Per cu. yd.
Labor	$61	$0.0650
Foreman	6	.0069
Superintendent	13	.015
Black powder	96	.1028
Giant	6	.0060
Fuse	3	.0027
	$184	$0.1984

Stripping at County Pit:	Total.	Per cu. yd.
Labor	$24	$0.0252
Superintendent	12	.0124
Team hire	12	.0134
Equipment rent	5	.0052
	$52	$0.0562

Hauling from County Pit, 2½-mile haul:	Total.	Per cu. yd.
Labor	$161	$0.1730
Foreman	6	.0068
Superintendent	27	.0346
Team hire	337	.3614
Equipment rent	94	.1000
	$625	$0.6758

Spreading 3,422.31 cu. yd.:	Total.	Per cu. yd.
Labor	$255	$0.0743
Superintendent	52	.0168
Foreman	58	.0153
Equipment	4	.00001
	$368	$0.1064

SURFACING.

Hauling Caliche from crusher to road, average haul, 5 miles, 2,496.89 cu. yd.

Loading at Crusher:	Total.	Per cu. yd.
Labor	$76	$0.0303
Foreman	20	.0082
Superintendent	16	.0062
	$112	$0.0447

Hauling:	Total.	Per cu. yd.
Labor	$608	$0.2475
Foreman	47	.0188
Superintendent	98	.0390
Team hire	1,274	.5141
Equipment rent	329	.1318
	$2,355	$0.9512

Total cost per cu. yd. delivering on road:	
Superintendent	$0.0452
Labor	.2778
Foreman	.0270
Team hire	.5141
Equipment	.1318
	$0.9957

Shovelers Loading Wagons, County Pit:	Total.	Per cu. yd.
Labor	$146	$0.1369
Superintendent	24	.0250
	$170	$0.1819

SPRINKLING, HARROWING AND ROLLING.

Sprinkling:	Total.	Per mile.
Labor	$148	$48
Foreman	32	11
Team hire	102	33
Fuel: Dist., $29.68; gas, $7.08	37	12
Misc.: Cells, $9.30; cable, $1.10; pipe, $2.68	13	4
Equipment rent	33	11
Superintendent	29	9
Equipment	31	10
	$426	$139

Harrowing:	Total.	Per mile.
Labor	$40	$13
Foreman	16	5
Teams	44	14
Superintendent	9	3
	$108	$35

Rolling 3.064 Miles:	Total.	Per mile.
Labor	$237	$77
Foreman	33	11
Superintendent	57	18
Team hire	82	27
Roller rent	231	75
Equipment rent	56	18
Oils: Cyl., $19.20; grease, $0.90	20	7
Fuel (coal)	241	78
	$956	$312

MISCELLANEOUS.

Labor	$203	$66
Team hire	83	27
Miscellaneous material	81	26
Horse and buggy	40	13
Superintendent	32	10
	$439	$143

Foremen received $100 per month; common labor $2. Team hire was $2.50 per day.

Purdue University Road School.

The annual road school under the direction of the school of Civil Engineering of Purdue University, will be held this month at Lafayette, Ind. The work will consist of a short course of illustrated lectures, laboratory demonstrations and conferences upon: Highway Construction, Highway Maintenance, Highway Bridges and Culverts, Road Drainage, Testing Road Materials. The Road School will occupy three days from Tuesday, Jan. 16, to Thursday, Jan. 18. It is intended for all those interested in the construction and maintenance of highways. The annual organization meeting of the State Association of County Highway Superintendents will be held on Wednesday evening, Jan. 17. Live question of road maintenance and reconstruction will be presented and discussed by the various highway superintendents of the state. The meeting of the Indiana Engineering Society occurs at Purdue University on Jan. 18-20. An exceptional opportunity is offered to county surveyors to attend both meetings the same week. The lectures will be practical and instructive, so that those attending will be equipped to be of material assistance in obtaining better roads for Indiana. The school will be under the direction of Geo. E. Martin, Assistant Professor of Highway Engineering.

ROAD BUILDING IN KANE COUNTY, ILLINOIS, WITH COUNTY OUTFITS.

Contributed by Geo. N. Lamb, County Superintendent of Highways

Two road building outfits, owned and operated by the county, are in use in Kane County, Illinois.

Outfit number one is an equipment for building gravel or stone roads. The machinery for preparing the gravel consists of a portable screen mounted on trucks, a jaw crusher, an elevator, a 15-cu. yd. storage bin and gasoline traction engine. The machinery for hauling, spreading and rolling the material consists of two steel-tired 5-yd. White motor trucks.

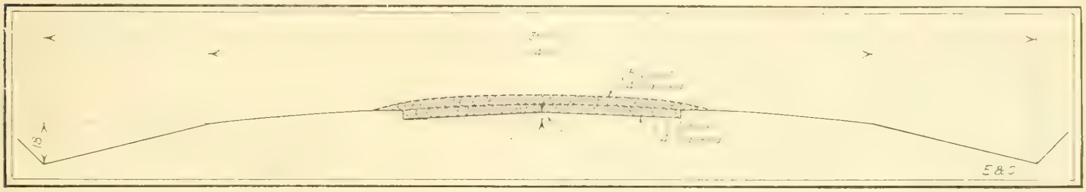


Fig. 1—Cross Section of 2-Course Road Construction, Kane County, Illinois.

The screen separates the coarser gravel from the finer, sending the former through the crusher, and the latter direct to the elevator; which receives in turn the crushed material, and conveys it to the storage bin. The screen is fed by an 18-in. by 40-ft. conveyor belt, the lower end of which is placed underneath a hopper to which the gravel is delivered by means of teams with slip scrapers.

The gravel is usually screened or crushed to a maximum size of 1½ in. In selecting a suitable pit for operating the machinery, it has been found desirable to have a large proportion of the coarser sized material and to avoid an excess of fine sand in the mixture. The coarser gravel and crushed material must be depended on for the wearing qualities of the road and there should be just enough of the sand together with the crusher dust to form the binder. The crusher will take anything up to 8 or 10 in. in diameter. For economy in hauling, the pit should be located not more than five or six miles from the road to be improved.

In loading, the trucks drive directly underneath the bin and receive their load from bottom dump gates. The time required to load a 5-yard truck does not exceed one minute.

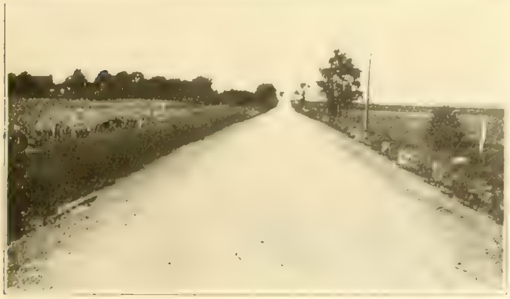


Fig. 2—View of 2-Course Stone Road, Kane County, Illinois.

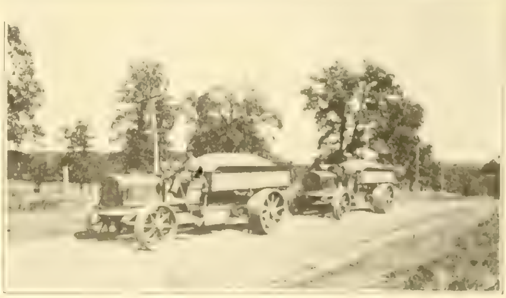


Fig. 3—Hauling Road Material in Motor Truck.

Both trucks have steel tires 20 in. wide each in the rear, and 10 in. wide each in front. The rear wheels are tapered; that is, the surfaces are pitched 1¼ in. so that the truck acting as a roller will conform to the crown of the roadbed. When the truck is loaded each rear wheel bears a weight of 4.9 tons. The entire road, whether it be the old roadbed or the newly deposited gravel, from the crusher to the point of construction receives the benefit of the rolling.

To unload, the body of the truck is raised or inclined at an angle of about 47 degrees, then as the truck moves forward the end gate is opened a given distance and the material is uniformly spread to the required depth, all operations being accomplished by the driver without leaving his seat. The graveling is begun at the end of the road nearest the pit, and thus each succeeding load contributes to the rolling of the material already placed.

For the resurfacing of old gravel roads, feather-edge construction is best adaptable to the motor truck equipment. For new work, excellent results have been obtained by depositing the material in two courses, using the trench method for the first course, keeping the earth shoulders at a level with the top of the gravel or stone and then allowing the top course to feather out a foot or two wider on each side than the bottom layer. Any depressions or unevenness appearing after rolling the bottom course may be relieved when the second coat is applied. If unusually bad or wet places appear in the subgrade, drainage is provided by digging a trench about 2 ft. square in cross-section extending from the center of the roadway to the side ditch and refilling with coarse stone or gravel.

The number two outfit consists of a 40-80 H.P. gasoline tractor, a 3½-ton, 12-ft. blade grader, a three-way road drag, a scarifier and a gasoline supply wagon.

The process of road grading may be summed up briefly as follows: A row of stakes is placed along each ditch line to assure good alignment and a uniform width between ditches. The ditch lines are then cut with the grader and all sod is brought to the center of the road. With the sods buried, the fresh dirt from the second, third or succeeding cuttings may be used to crown the roadway. Ditches are cut 18 to 24 in. deep and may be 36 to 50 ft. apart.

An oval surface is produced extending between the bottoms of the two ditches. Sidehill work requires special attention. In some cases it is necessary to secure all the dirt from the uphill side, bringing the bottom of the ditch to the required depth below center grade line.

Earth roads graded by means of the heavy traction engine possess the advantage of being thoroughly compacted. When the road is finally shaped with the grader the three-way drag is employed, which, together with the engine, tends to further smooth up and uniformly compact the surface. A roadbed thus formed will absorb a minimum amount of water and may be maintained at a minimum cost.

Before the advent of the automobile many of the roads of Kane County were graded up 2 or 3 ft. high, with steep side slopes and with a top width of 9 to 15 ft. The surface may have received one or several coats of gravel.

In reconstructing a road of this kind and preparing it for a hard surface the stakes on the ditch lines are set so that their tops are at the profile grade. The old gravel is scarified, and then by cutting down the old grade, or by bringing in new material from the ditch lines, or often by a combination of both, the grader man sighting across the tops of the stakes is able to bring the new roadbed to the proper level and cross-section, the entire operation being accomplished with the machinery.

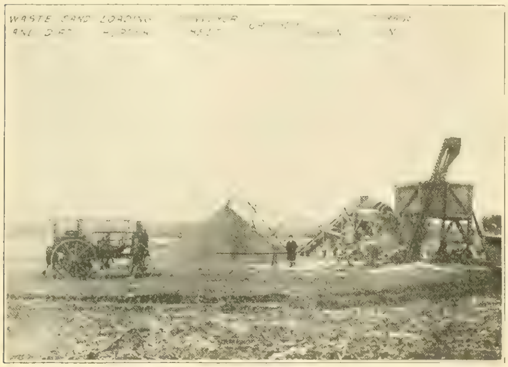
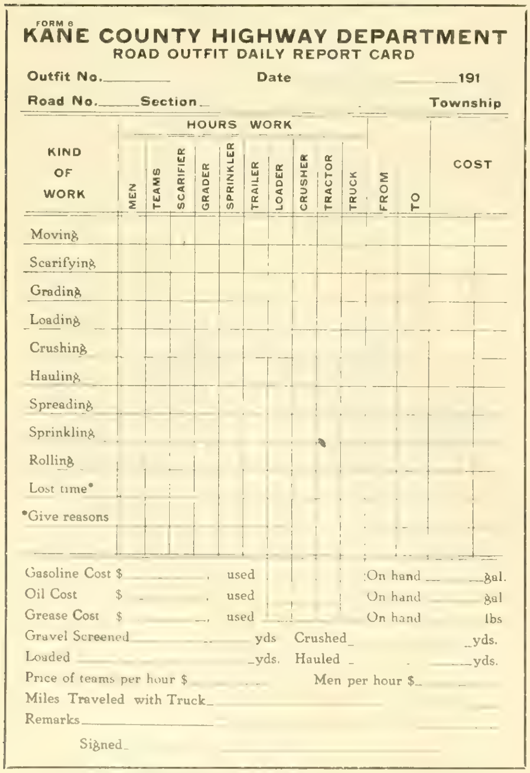


Fig. 4—Crusher Outfit of Kane County.

The outfits are under the direct supervision of the County Superintendent of Highways. Township highway commissioners desiring to receive the benefit of the machinery make a written application, which is virtually a contract on their part to pay the actual operating costs, such as fuel, oil, supplies and the salaries and board of the operators, and to furnish such additional labor, teams, etc., as may be necessary for carrying on the work.



FORM 6

KANE COUNTY HIGHWAY DEPARTMENT

ROAD OUTFIT DAILY REPORT CARD

Outfit No.________ Date ________191

Road No.______Section_ Township

KIND OF WORK	HOURS WORK												COST
	MEN	TEAMS	SCARIFIER	GRADER	SPRINKLER	TRAILER	LOADER	CRUSHER	TRACTOR	TRUCK	FROM	TO	
Moving													
Scarifying													
Grading													
Loading													
Crushing													
Hauling													
Spreading													
Sprinkling													
Rolling													
Lost time*													
*Give reasons													

Gasoline Cost $ ______ used ______ On hand ______ gal.
Oil Cost $ ______ used ______ On hand ______ gal
Grease Cost $ ______ used ______ On hand ______ lbs
Gravel Screened ______ yds Crushed ______ yds.
Loaded ______ yds. Hauled ______ yds.
Price of teams per hour $ ______ Men per hour $ ______
Miles Traveled with Truck ______
Remarks ______
Signed ______

Fig. 5—Daily Report Card. (Actual Size 4 In. by 6 In.)

To meet current expenses the County Board makes an appropriation to the County Highway Department. This original fund is placed in a local bank. The fuel, oil and supplies are purchased, and the salaries of the operators are paid from this fund. Thus the operators are regarded as county employes. At the end of each week a statement of the actual operating cost is rendered to the township commissioners, who usually meet only once or twice each month. Duplicates of the statements are kept and an entry is made in the ledger. When the money is received from the commissioners the ledger is balanced, the check is deposited in the bank and the fund is kept replenished. All payments for labor and supplies are paid by special vouchers, which, when endorsed, become a receipt in full for all items thereon indicated.

Each man in charge is required to fill out and mail to the County Superintendent of Highways daily report cards (see Fig. 5). The cards give detailed information and costs regarding every operation connected with the work, as well as the supplies consumed and the amount of material handled. The report cards give the cost of men and teams furnished by the township, as well as those paid directly by the County Department. When these cards are received at the office entries are made in the cost data books. On completion of each road itemized costs are readily obtained.

The following two illustrations of costs are given. The work in Dundee Township was done mostly during the months of January, February and March, 1916, and includes such items as garage rental, lost time due to bad weather, softness or slipperiness of roads, freezing of the gravel pit, and other obstacles which would not be encountered in summer weather.

The work in Sugar Grove Township was done under average summer weather conditions. In both instances the gravel was screened and crushed:

COST OF WORK IN TWO TOWNSHIPS.

	Doundee Township. 1 truck used.		Sugar Grove Township. 2 trucks used.	
		Per cu. yd		Per cu. yd.
Number of cu. yds. screened, crushed and hauled	2,461	....	2,512	......
Average distance hauled (miles)	1	. .	3	......
Number of days hauling	60	.	45	.....
Number of days lost time	26½		13	......
Total cost of feeding screen hopper	$541.60	$0.22	$575.50	$0.229
Total cost of screening and crushing	523.41	21	357.44	.142
Total cost of hauling	574.61	22½*	911.14	.363†
Total cost of spreading	105.60	.04	120.10	.048
Total cost of rolling	....	.....	....	.....
Total cost of moving and setting up machinery	65.50	.03	143.50	.057
Total cost of all operations	$1,810.72	$0.72½	$2,107.68	$0.839

*Per yard mile, 22½ cts.; per ton mile, 15 cts. †Per yard mile, 12.2 cts.; per ton mile, 8.1 cts.

The cost of rolling given above is $0.00, because in neither of these instances was any extra rolling done other than that accomplished by the regular hauling. Some extra rolling has been done, however, in other instances. Lost time indicates time paid for in which no hauling was done.

Present Status of Experimental Wood Block Pavement at Minneapolis, Minn.

Inspection of the experimental piece of treated wood-block pavement, laid in 1906, by the city of Minneapolis in co-operation with the Forest Service and various lumber manufacturers and wood-preserving companies, has revealed the fact that white birch is wearing as well as longleaf pine, and that sapwood of timber if well treated is practically as durable as heartwood. Data thus far recorded and analyzed at the Forest Products Laboratory at Madison, Wis., indicate that in order of efficiency the six species used in the experiment rank as follows: (1) longleaf pine and white birch; (2) Norway pine; (3) tamarack and eastern hemlock; and (4) western larch. Douglas fir blocks were also included in the experiment, but were laid at a later date than the other species and no definite conclusions in regard to their relative durability can be drawn at this time.

When this pavement was laid the traffic on it was principally steel-tired, horse-drawn trucks, with few motor vehicles. It now consists of light and heavy motor vehicles with only a few horse-drawn trucks.

GRAVEL ROAD CONSTRUCTION AND MAINTENANCE IN WISCONSIN.[*]

Very few of our gravel pits contain material that conforms to our ideas of a good road gravel. In some cases it does not contain binder enough, and clay must be added. Again, it may contain too much of either clay or sand, or both, and a portion must be removed by screening. Where gravel contains many stones larger than 2 in., in their longest dimension, we crush it, as it is eventually just as cheap and gives us a much more uniform material, thereby greatly reducing the future maintenance cost.

If we could contract for the manufacture of gravel pits, our specifications would provide for a uniform mixture of angular stone from ¼ in. to 1½ in. in size, with just enough clay and good sharp sand evenly mixed to fill the voids. This would result in about 85 per cent of stone from ¼ in. to 1½ in. in size, and 15 per cent binder material. However, it is impossible to find many pits that conform to these specifications, and we have come to the conclusion that a good road can be built of any kind of gravel, if a reasonable amount of intelligence is used in directing its construction.

Construction.—Our surveys, plans and cross sections for gravel roads are the same as for other types of surfacing, and standard concrete culverts are built. The grade is made somewhat wider than necessary for the present gravel surface in order to accommodate a wider surface when traffic conditions demand it, and no sod or vegetable matter is allowed under the surfaced portion. Where necessary, we provide under-drainage, and insist upon just as good a foundation for a gravel road as for any other type, as it is impossible to get a good surface on a poor foundation. The subgrade is prepared by cutting out a trench the full depth and width planned for the finished surface and having the same crown. Side drains are constructed to insure a dry subgrade in event of rains during the course of construction. On clay soils the subgrade is rolled before placing the material, the purpose being to develop the weak or soft spots, if any.

Pit-Run Gravel Roads.—In building a pit-run gravel road we remove the large stones, if any, at the pit, preferably by the use of an elevator and screen, delivering the gravel to the elevator by the use of wheelers or fresnos. If extreme care is used, they may be removed at the time of loading by the use of 5 or 6-tine forks. The latter method is not recommended and is satisfactory only on small jobs.

Loads of exactly the same size in length, width and depth should be hauled, and be sure they are dumped so that each covers the same length and width, insuring an even depth of material. To use uneven loads, with the ordinary method of spreading, is sure to result in an uneven surface.

We build practically all of our gravel roads in two courses, plus the binder necessary, spreading the first course evenly to a loose depth of not to exceed 6 in. and generally beginning at the end nearest the pit and hauling over the material as the work progresses. This method will save some rolling.

The first course is gone over several times with a road plane or light grader, with blade set nearly at right angles, to insure an even surface before rolling. After properly rolling the first course, we start the second course at the farthest end from the pit and work towards it, spreading the material to a loose depth of about 5 in. and harrowing thoroughly with a heavy peg-tooth harrow before rolling. Most pits run uneven; the harrow will tend to mix the material and will also bring the coarse stone, if any, to the surface, where they can be raked off. If the gravel will not bind readily, it may be necessary to harrow in clay to help in bonding, which can be done at the same operation, but care must be exercised in the application of clay, as an excessive amount may cause the surface to rut during wet weather. We again use the light grader a sufficient number of times to insure the removal of all wavy appearance and give to the surface a proper crown.

It is often necessary to use the grader a second time after the rolling has been started to remove all of the wavy appearance. The voids in the surface, if any, are filled with fine gravel, then rolled thoroughly and flushed.

Better results may sometimes be obtained by thoroughly wetting the material and allowing it to dry to such an extent before rolling that the binder will not pick up on the wheels of the roller. This method insures the proper bond from the bottom up. It is difficult to advise the proper amount of water for a pit run gravel road, as no two sections can be treated alike. If possible, we open the road to travel while the roller is yet on the job, and if ruts appear, fill them at once by using the light grader or road plane and roll until thoroughly compacted. Provisions are made for following up with maintenance immediately if necessary, as well as surface treatment when the surface becomes well cured.

It requires no more material to build a high class gravel road than one you must apologize for every time you have occasion to travel it, the difference in cost being mostly chargeable to extra care in the methods of construction, which adds but little to the total cost of the work.

Crushed and Screened Gravel Roads.—In many of our eastern and southern counties we have numerous gravel pits of excellent quality, but usually containing a rather high percentage of large stone, and many containing an excess of binder. To handle this particular kind of gravel economically and get the very best results, we find it necessary to crush and screen it. We use an ordinary portable jaw crusher with screen and bins, having a capacity of from 80 to 120 cu. yd. per day, usually equipped with conveyor and grizzly screen which removes the fine material and transfers it to the elevator, allowing only the coarse stone to pass through the crusher jaws, which increases the capacity from 20 to 40 per cent.

The crushers are equipped with a three-compartment portable bin, with 35 to 50-cu. yd. capacity, and two section screen, each section 30 in. in diameter and 4 ft. in length. The first, or lead section, having 1½-in. perforations, and the second section 1¾-in. perforations, which separates the material into three sizes. The No. 1 size consists of material refusing the 1¾-in. ring; the No. 2 size the material refusing the ½-in. ring and passing through the 1¾-in. ring; the No. 3 size, the material passing through the ½-in. ring. The crusher jaws are adjusted so as to produce about equal proportions of the No. 1 and No. 2 sizes.

The subgrade is prepared the same as described for pit run gravel, but construction is started at the end of the road farthest from the gravel supply. The first course consists of No. 1 material spread to a loose depth of about 6 in., and well rolled, the voids having been filled with the necessary amount of No. 3 material. This course is laid for a distance of about 400 ft. before starting the second course.

The same care is exercised in having uniform loads delivered and evenly spread. The second course consists of about 5 in. of No. 2 material, evenly spread and rolled, the voids well filled with No. 3 material, the surface brought to the proper crown with a light grader, then thoroughly rolled and flushed in practically the same manner as a stone macadam road.

Some pits contain quite a percentage of clay, and in this case a heavy harrow is used to work in the No. 3 material, thereby greatly benefiting the finished road. In some cases there is a surplus of No. 3 material which is distributed at convenient points along the road for maintenance purposes, or used for surfacing private entrances or road intersections.

In many instances better results are obtained by crushing the gravel fine enough for practically all the material to pass through the 1¾-in, ring, and carry over into the No. 2 material, just enough of the No. 3 or bonding material to fill the voids in the No. 2. This is accomplished by placing a sheet iron jacket around the lower three-fourths of the first section of screen, which does not permit all of the finer material to pass through the ½-in. perforations, but carries over into the bin with the No. 2 material, the necessary binder. This must be regulated so as to just fill the voids in the No. 2 material with the No. 3, and no more.

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[*] Abstract of a paper presented [illegible] before the Northwestern Road Congress by J. T. Donaghey, Chief Inspector Wisconsin Highway Commission.

The balance of the No. 3 material will naturally drop into the No. 3 bin and may be used in finishing the surface where additional binder is required, or for future maintenance and other purposes. By pursuing this method, both first and second courses are built of the same sized materials and results in a type of road which is easier to build, cheaper to maintain, and one which generally gives better satisfaction than any other type of gravel road. Where clay is used to assist in binding or where there is naturally an excessive amount of clay in the gravel, it is advisable to place a covering of sharp sand or gravel on the finished surface to protect it until the excess clay has worked to the surface and washed off.

We take just as much care in finishing a gravel road as one costing three times as much, trimming up the shoulders properly and cleaning out the ditches so the water can get entirely away from the road immediately after each rain. The last $50 spent in an intelligent manner for shaping and trimming up any mile of road stands out more plainly than does any other $100 spent on the same road.

Maintenance.—The maintenance of our pit run gravel roads consists chiefly in the application of new material where necessary, shaping up the surface with a road plane or light grader, the removal of stone that may appear on the surface, and cleaning out the ditches and culverts. This work is done as early in the season as possible, one of our counties having shaped up over 50 miles during the month of April, 1916, by the use of a motor truck pulling two road planes covering a width of 18 ft. An average of 10 miles per day was completed at a cost of less than $5 per mile, including the removal of loose stone from the surface. When new material is added the road plane is used to even up the surface before it becomes thoroughly compacted. A cheap light oil is often used to advantage in the maintenance of this type of gravel road, but we do not advocate the heavier oils for the reason that the wearing surface is liable to be somewhat uneven in quality, the soft or loose spots invariably pitting out, which is anything but satisfactory.

The maintenance of our crushed gravel roads consists in placing new material where necessary each year, a surface treatment with a good asphaltic oil or refined tar, and cleaning out all ditches and culverts.

It is customary when the crushing machinery is located in a gravel pit to crush an additional amount of material to be used for future maintenance. Some counties haul this material during the winter months, which generally reduces the cost to a considerable extent. It is deposited in large piles near the roadside and used as needed. The surface treatment is applied in the same manner as on a stone macadam surface. The surface is swept perfectly clean with a power sweeper, followed by hand brooms to insure the removal of all vegetable matter and dust pockets. About 0.6 gal. of bituminous material is used per square yard and applied with a pressure distributer. A covering of about ¼ in. of fine gravel or torpedo sand is used which, with the bitumen, forms a carpet that protects the wearing surface.

A system of patrol maintenance should follow this surface treatment as spots are liable to appear that require an additional amount of bitumen, which, if not taken care of immediately, will cause holes to appear in the road surface that will be very disagreeable.

NEW HOSE EQUIPMENT FOR HAND FLUSHING IN NEW YORK CITY.

An improved type of hose equipment for hand flushing is now in use by the Department of Street Cleaning of New York City. Previous to 1915 it had employed ordinary 2½-in. fire hose and 1¼-in. nozzles. This was carried on the regular sweepers' can carrier or dragged over the pavement by sweepers. As a result of studies and experiments the department has adopted the 2-in. size as standard for the city, and has developed a new hose reel and new hydrant equipment. The following description of the New York equipment and principles is taken from a paper by Raymond W. Parlin, formerly Engineer with the New York Bureau of Municipal Research, prepared for the last annual convention of the American Society of Municipal Improvements.

As a result of the experiment the following general principles for hand flushing appear to have been established:

General Principles of Hand Flushing.—(1) That the economical size of equipment is dependent upon the hydrant pressures available and the length of hose used.

(2) That when the pressure at the nozzle is in excess of 25 lb. per square inch, water is delivered through a ¾-in. or 1-in. nozzle faster than it can be properly used by two men and that it is accompanied by excessive splashing.

(3) That when the pressure at the nozzle is less than 18 lb. per square inch, water is not delivered fast enough to keep up with the men nor with force enough to enable them to do effective work.

(4) That the smallest size hose which will give pressure at the nozzle between 18 and 25 lb. is the most economical for use.

(5) That better results can be secured by spraying ahead as far as the stream will reach, to give the material on the street a preliminary soaking prior to the direct flushing, than can be secured by the direct flushing of a dry pavement.

(6) That larger quantities of water are required to clean rough pavement than smooth, and therefore a slightly larger nozzle may be used to advantage. (It is estimated that a ¾-in. will be satisfactory for asphalt and a 1-in. for rough Belgian block.)

(7) That shut-off nozzles are necessary whenever working in traffic, both to save water and to prevent accidents.

(8) That where water mains are large enough for proper domestic and fire supply, flushing will not interfere with the ordinary household use.

(9) That a hose reel will enable the gangs to do more work with the same expenditure of energy and at the same time lengthen the life of the hose.

(10) That by the adoption of procedure which prevents any "back tracking" of the equipment, over four miles of walking can be saved per gang per 8-hour day in covering a given amount of street, as compared with the procedure commonly used in the past, which saving enables the gangs to do more work.

Procedure in Handling Equipment.—The procedure in handling the equipment may be described as starting with the hose reeled so that the nozzle is on top or outside; commencing to unreel when at a distance equal to the length of the hose from the hydrant; unreeling toward the hydrant; placing the reel on the sidewalk near the hydrant; flushing from the point nearest the nozzle past the hydrant and as far as the hose will reach beyond the hydrant; and reeling from the hydrant toward the nozzle; thus completing the area served by a single hydrant. Whenever moving the hose, the "hydrant man" is required to pick it up in loops and drag it ahead in such a way that it will not cross other loops. He is expected to keep a loop at the nozzle end, even with or slightly ahead of the "nozzle man," so that the latter will be free to move without assistance at all times.

Equipment.—The New York equipment consists of an improved reducer which can be put on the hydrant without the use of a wrench and an improved reel with its tool box, third wheel, and special arrangement for receiving the reducer in winding on the reel.

The first cost of the equipment is approximately as follows:

Three 50-ft. lengths 2-in. rubber hose at 60 ct. per ft.	$ 90.00
One ¾-in. shut-off nozzle	7.00
One 2½-in. to 2-in. reducer, hand swivel type	2.25
One hydrant key	.15
One hose reel	30.00
	$129.40

(Rubber-covered hose is preferable to cotton-jacket hose for this work.)

The cost of operating with this equipment is as follows:

ANNUAL AND UNIT COSTS BASED ON 200-DAY SEASON AND ONE 8-HOUR SHIFT PER DAY.

Conditions.

Dirty Belgian block pavement; night work.
Force, 1 gang.
First cost equipment, $130; hose, $90.
Life hose, 250 working days; other equipment, 1,200 working days.
Interest at 5 per cent. Water at 5 ct. per 1,000 gal.
Area flushed per shift, 23,000 sq. yd.
Area flushed per year, 4,600,000 sq. yd.

Fixed Charges.

	Per year.
Depreciation reserve (hose not included)	$ 7.00
Interest	6.50
Maintenance:	
Repairs and painting	15.00
Storage	20.00
Operations:	
Hose	72.00
Laborers, 2 at $2	800.00
Water, 900 gal. per 1,000 sq. yd.	207.00
Total annual cost	$1,127.50
Cost per 1,000 sq. yd.	24.5 ct.

When cleaning 20,000 sq. yd. per day the cost per 1,000 sq. yd. is 19.8 ct.

Upon less heavy work and smooth pavements New York gangs have been able to flush effectively 30,000 or more square yards in 8 hours, making as many as 45 connections to hydrants.

Conference on Highway Construction and Maintenance at University of Pittsburgh.

The Pennsylvania State Highway Department will again co-operate with the University of Pittsburgh in offering a conference on highway construction and maintenance in Thaw Hall, University of Pittsburgh, from Jan. 29 to Feb. 3, inclusive.

While the course is intended to be a continuation of the subjects discussed during last year's short course in highway engineering, the conferences will be so arranged that those not present at last year's course may take up the work with those who were in attendance last year. The leaders in the discussion of the various subjects, will be selected from the State Highway Department officials, School of Engineering faculty and others who are interested in the various branches of the work. Plenty of opportunity will be given for the presentation and discussion of problems arising in the work of those in attendance.

As at the short course in highway engineering last year, an important part of the conference will be the laboratory work in the testing of the materials of highway construction. A new building for housing this laboratory is now in process of erection and will be completed in time for use during the conference. In order to secure the maximum value from this phase of the work, it is suggested that those desiring tests of materials send their samples for test to Professor L. C. McCandliss not later than Jan. 15, 1917. No charge will be made for such tests to those later attending the conference. To others the fee for tests is nominal.

All those interested, including state, county and borough officials and contractors, are cordially invited to attend and participate. It is especially hoped that township road supervisors will avail themesives of the opportunity offered in these conferences, as during the coming year the townships will play an ever increasing part in the construction and maintenance of our highways. A registration fee of $5 payable at the beginning of the conference, is charged for those attending. A special folder giving other information will be mailed upon receipt of request by John W. Hallock, Secretary of the Highway Committee, University of Pittsburgh.

FEDERAL PARTICIPATION IN ROAD WORK.

The conditions that must be met by the states in order to share in the $75,000,000 federal appropriation for road construction were outlined by James T. Voshell, District Engineer, U. S. Office of Public Roads, in a paper presented Dec. 7 at the Northwestern Road Congress. Mr. Voshell's discussion, in part, follows:

In general, the act provides that the state highway departments shall initiate schemes, projects and plans for co-operate road work in their respective states, and gives the Secretary of Agriculture general authority to approve or disapprove them. If the authority to approve or disapprove were exercised autocratically it might be possible for the federal authorities to compel the work to be done along hard and fast lines laid down by them and practically set aside the right of initiative of the state authorities. Such action, however, would entirely prevent co-operative work between the federal and state agencies, without which federal participation in road work is foredoomed to failure. No one is more anxious than the federal officials to make this work truly co-operative, and friendly consideration will be given to all schemes, projects and plans that may be proposed by the state highway departments.

While the act of Congress authorizes the Secretary of Agriculture to co-operate with the states in the construction of rural post roads, it also, to a considerable extent, sets out how he may co-operate and outlines certain things that the states shall do if they desire their proportional parts of the federal aid funds.

One of the specific requirements of the act is that the state is required to assent to the conditions of the act of Congress. A mere formal assent is not sufficient. The state should provide the necessary machinery and funds for performing its part of the work. A state highway department, empowered to initiate and execute the construction of any road logically a part of a state highway system and authorized to co-operate with the proper federal officials, an appropriation equal to the state's portion of the federal fund, and a provision for maintaining the roads that may be constructed, are essential. It is probable that few state legislatures have authority to make appropriations extending over a 5-year period, but legislation should be passed providing for the necessary funds so far as is practicable.

The act, in providing that only a portion of the amount appropriated should become available each year for 5 years, initiates a 5-year program of work. It is true that projects might be submitted from time to time from one community or another to the extent that the federal appropriation would be used up. But the result might be that a number of short sections of road, scattered over the state, would be improved which would not serve as a part of or as logical branches to a state system. Therefore, in order that the roads constructed during the five years may form a complete structure or units of a structure already begun or contemplated, some fairly well-defined plan should be formulated by the state highway department. And when the department has formulated such a plan it should be revealed to the federal officials if true co-operation is to be had between them and the state officials. The plan need not be an actual layout of all the roads which it is proposed to improve, but it should be such as to indicate what the state officials plan to do and hope to accomplish.

It will be necessary for a great many of the state legislatures to enact amendatory laws providing for federal participation, and they will expect their highway departments to advise with them as to what laws should be passed. This the departments cannot do intelligently unless they have a fairly definite plan of work in mind. And proper legislation may be a solution of four-fifths of the difficulties encountered by the state highway departments in this co-operative work. For example, it is fair to assume that each county, at least, will insist that it have a share of the federal appropriation. This may be accomplished in several ways, three of which are as follows: First, a short section of road could be improved in each county, but such a procedure probably would prove unsatisfactory both to the federal and state officials; second, the federal aid fund could be combined with state-aid funds and apportioned among the counties, but the result of this might be the improvement of a number of short sections of roads and be annoying to the state as well as the government on account of the necessary joint procedure for each project; third, the federal fund may be considered as a part of the state-aid fund, but be applied on certain projects in certain counties, thereby releasing a like amount of state funds to be allotted among the various projects in the other counties. So it is that there are several solutions to practically every one of the problems that will come up, and it is important that the best one be found and enacted into law.

Furthermore, thought should be given to secure such legislation as will give the state departments considerable latitude in the selection of roads to be improved with the aid of the federal funds, as these funds can only be used to improve "any public road over which the United States mails now are or may hereafter be transported."

To secure federal aid for improving a particular road a project statement should be prepared, setting forth full information relative to the proposed improvement, signed by the official or officials of the state highway department authorized to sign such contracts, and forwarded to the Secretary of Agriculture. If the project as set forth in the project statement appears to be a meritorious one, the state department will be so informed, and should proceed to make the necessary surveys, plans and specifications and a detailed estimate of cost and forward them to the Secretary of Agriculture for approval. It is impractical to make any hard and fast requirements relative to the details of construction, as the local conditions concerning each project will have to be taken into consideration. However, the state officials will experience no difficulty in having their plans approved if they study the traffic needs of the communities served by the road and plan an adequate and substantial improvement.

The act of Congress authorized the Secretary of Agriculture to co-operate only with state highway departments. Therefore, they alone can initiate projects, and it will be time wasted for county or township officers or officers of associations to petition the federal officials to improve any particular road under the provisions of this act.

When the plans, specifications and estimates have been approved by the secretary he will certify the fact to the Secretary of the Treasury, who will set aside funds to pay the government's portion of the cost, and to the state highway department, which will proceed to construct the improvement by contract or day labor, as it deems advisable. Engineers of the Office of Public Roads, representatives of the Secretary of Agriculture, will inspect the work as it progresses, and should it be found that it was not being done according to the approved plans and specifications, payments from the government fund would be withheld.

Payments from the government fund will be made from time to time as the work progresses or upon its completion. These payments will be in the form of a reimbursement—i. e., the state will first pay for the work, and when it has done so, upon certification to the proper government official of the amount of work done and the amount paid, the government's portion will be paid by check drawn in favor of the official authorized to receive it, in general, in favor of the state treasurer. Legislation may be necessary to authorize the state treasurers to receive the federal funds, to credit them to the proper projects and to disburse them upon certificates of the state highway department, as some state treasurers are only authorized to pay out funds in accordance with appropriations made by their state legislature.

As evidence on the part of the government that it desires to co-operate with the state highway departments, the United States has been divided into ten districts and a district engineer of the Office of Public Roads has been assigned to each. Therefore, a representative of the government will be readily available to take up personally with the state officials all matters pertaining to the administration of this act.

CONCRETE PAVEMENT AT SIOUX CITY, IOWA.

About 65 miles of concrete pavement have been laid in Sioux City, Ia., and this type of construction has proved very successful there. In a paper presented at the recent convention of the American Society of Municipal Improvements, Mr. K. C. Gaynor, formerly City Engineer of Sioux City, describes the method employed in constructing the first pavement. The paper, practically in full, follows:

The subgrade was finished as for any pavement. The streets paved varied in width from 24 to 52 ft. The concrete was mixed 1-3-4½ and the pavement was laid 5 in. thick. The sand was a fairly clean bank sand, and the stone came from the Sioux Falls, S. Dak., district, being a hard jasper.

The concrete was mixed fairly wet, and was first floated with a long-handled wood float. Then a mixture of half sand and half cement was sprinkled on it in sufficient amount to take up the surplus water, and to cover any stones which might have been uncovered by the first floating, and was then floated again. No templet or screed was used, the grade being obtained by eye.

One-inch expansion joints were placed across the street every 25 ft. and along the curbs, and contraction joints, which were just cuts, were placed in between the expansion joints and also parallel with the street, this leaving the concrete in blocks about 12 ft. square. After the first ½ mile of pavement was laid, the concrete joints were omitted owing to the difficulty of making them, and only the expansion joints retained.

One-inch boards were used in the expansion joints and after the concrete had set the boards were removed and the joints filled with bitumen. The edges of the joints were carefully tooled and considerable effort expended in order to get the surface of the concrete at both sides of the joint at the same elevation.

The concrete was laid on grades up to 16 per cent. On grades over 7 per cent the surface was corrugated by marking the concrete every 5 in.

As the time has passed, the main points of construction have been continued, except that the specifications have been changed so as to require a richer mix, and the thickness has been increased to 6 in., and in some places more, depending on the street, and elastite has been used in the joints on account of the greater ease in construction.

These streets now, after 5 years' use, are still in good condition, and do not show enough wear to make it possible to estimate their probable life. Very few cracks have developed, and inasmuch as the few cracks that have developed and the expansion joints have been taken care of by filling with tar and sand about twice a year, the cracks have not been objectionable except as for looks. Neither the joints nor the cracks have raveled out.

About 65 miles of streets and roads have been built in Sioux City up to date of this type of construction, and very little other pavement has been laid.

The maintenance of this concrete pavement has been practically nothing. The only cost being the filling of the joints as above mentioned.

Concrete paving is also laid between the car tracks and the service company now uses it as a standard type of construction on all streets, including those paved with asphalt.

The points of construction upon which the greatest emphasis has been laid are clean, well-graded sand, hard stone, and much work and care taken with the finishing. This matter of finishing is very important, and too much stress cannot be laid upon it.

CONCENTRATION OF TRAFFIC ON HIGHWAYS.

During 1916 the officials of Essex County, New Jersey, took a traffic census at 81 different points in the county. These stations varied from the heaviest traffic points in the vicinity of Newark and extended out into the country at the principal points of intersecting roads. In addition to counting the traffic, special observations were made to determine where the density of traffic was, and also particularly as to the traffic in the various portions of the roadway. The results of the census are given in the recently issued report of Frederick A. Reimer, County Engineer, for the year ending May 10, 1916, from which the matter that follows is taken:

Five different conditions were encountered, namely:

Roads having double trolley tracks in the center of the road;

Roads having double-track trolley line, one track on either side of the roadway;

Roads having a single-track trolley line in the center of the roadway;

Roads having a single trolley track line on the side of the roadway;

Highways where the center of the highway only was paved.

The first condition, with the tracks in the center of the highway, presents the following results:

On roads with 50 ft. or greater between curbs and on sections of these roads where there was no great number of business houses, 5 per cent of the traffic used the 15-ft. strip of the road on which the trolley tracks were laid; on the 10-ft. strip immediately adjoining the tracks on either side, making a total used width of 20 ft., 80 per cent of the traffic was counted. The balance of the width of the entire roadway, or the strips nearest the curbs, carried the remainder of the traffic, 15 per cent.

The result on the tonnage basis, using the percentage above stated, vary, of course, with the amount of traffic, the highest being 15½ tons per foot of width on trolley tracks, to 185 tons per foot of width on the 20-ft. strip, 10 ft. on either side of the tracks; and 36 tons per foot of width on the strips adjacent to the curb.

On sections where there is a congestion of business it was found that 20 per cent used the trolley tracks; 65 per cent used the 10-ft. strip on either side of the tracks, making a total used width of 20 ft., and 15 per cent used the strips on either side adjacent to the curbs. The tonnage under these conditions, taking the highest observed, was 61½ tons per foot of width on the trolley tracks; 150 tons per foot of width on the 20-ft. strip; 53 tons per foot of width on the strips adjacent to the curb.

On condition No. 2, with the trolley tracks on either side of the highway, the results were as follows: 95 per cent of the traffic used the center of the road, between the trolley tracks, and 5 per cent of the traffic used the strips on each side of the tracks. The highest tonnage on this basis was 111 tons per foot of width in the center of the road, and 12 tons per foot of width on the balance of the road.

On condition No. 3, with single track in the center of the road, the entire traffic used the space outside of the tracks. The highest tonnage was 66 tons per foot of width of roadway.

On condition No. 4, with single track only on the side of the road, the traffic used the space on the outside of tracks, the highest tonnage being 83 tons per foot of width.

On condition No. 5, with the center portion of the roadway paved to a width of from 16 ft. to 20 ft., it was found that the 10-ft. strip in the center of the road carried 75 per cent of the traffic, and the strips on either side of this 10-ft. center portion carried the remaining 25 per cent. The highest tonnage found on this condition per foot of width of road was 144 tons on the 10-ft. center strip and 62½ tons per foot of width on the two side strips.

On all but 12 points counted the percentage of motor-driven vehicles was above 50 per cent, and at some points the percentage was as high as 85½ per cent.

STEEL PLATE SURFACED PAVEMENT.

An experimental steel plate roadway surfacing was laid recently at Charlotte, N. C. The section occupies an area 18 ft. by 80.7 ft. on West Ave., the total yardage being 160.66. The completed pavement consists of a 4-in. base of crushed stone, thoroughly compacted with a 10-ton steam roller, a 3-in. top of fine aggregate concrete, mixed 1:2:4, and the steel surfacing set flush with the net grade.

Perforated Sheet Just Before Laying.

The steel surfacing is made from plates 2½ ft. x 18 ft. and ⅛ in. thick. The plates are perforated and the steel in this shape cost $50 per ton. Each perforation is 2 x 1½ x 1¼ in. in size and spaced 1 to 1½ in. apart. The metal at one side of each perforation is bent downward. The sheets are jointed together by tongues 1 in. square spaced 6 in. apart which fit into slots on the adjoining sheet. The crushed stone base cost 30 ct. per square yard. The entire cost of the work was as follows:

Finished Pavement Under 10-Ton Roller.

Base, 4 in. thick	$ 48.00
Materials for concrete top, 3 in. thick	61.90
Steel surfacing, delivered	150.77
Labor, including overhead expense	10.00
Total	$270.67
Total cost [illegible] per square yard	

The steel surfacing was invented and patented by J. F. Wixon of Hammondsport, N. Y. S. H. Lea is City Engineer of Charlotte, N. C.

Moving a 100-Ton Culvert.—A complete concrete culvert weighing at least 100 tons was moved recently for a distance of one-half mile by Shelby County, Iowa. The culvert was a 6x6 box, 30 ft. long, with coping and flaring wing walls, and was raised and mounted on a house moving outfit. A road change made the culvert useless in its old location.

MAINTENANCE COSTS OF CONCRETE ROADS IN ILLINOIS.

The average cost of maintenance and upkeep of concrete paved streets and roads in Illinois in 1915 was 0.4 ct. per square yard. This figure is the average for 75.3 miles of state aid highway, aggregating 555,013 sq. yds. of paved surface. The average cost of maintenance for 6.06 miles (56,554 sq. yd. of pavement) on township aid concrete roads in 1915 was 0.81 ct. per square yard. These figures are taken from a tabulation compiled by B. H. Piepmier, Maintenance Engineer, State Highway Department. The detailed costs for maintenance of the concrete slab only for the various roads are given in Table I. In this table the supervision and overhead items include portions of the salary and expenses of the Chief of Bureau of Maintenance, of his assistants and of the Division Engineers, which are chargeable to the work of maintenance and upkeep. Supervision and overhead amounts to 10.83 per cent of the money actually spent for maintenance and upkeep, or 0.10 per cent of the first cost of construction. The cost of maintenance and upkeep for the year amounts to 0.94 per cent of the first cost of construction.

TABLE I—MAINTENANCE COST OF CONCRETE ROADS IN ILLINOIS IN 1915.

State Aid Roads.

Description								Maintenance of slab.						
County.	Section.	Route.	Length.	Width.	Metal shoulders.	Sq. yds. pavement.	Date of acceptance.	Labor.	Material.	Transportation.	Equipment.	Supervision and overhead.	Cost of maintenance.	Cost per sq. yd.
Adams	A	5	8,200	10	Mac. 4-ft.	9,111	1915	$23.65	$14.86	$3.65	$5.35	$5.76	$53.27	$0.0059
Boone	B	1	4,600	10		5,111	1915	6.00	4.87	2.59	3.90	2.11	19.47	.0038
Cass	A	5	3,900	10		4,332	1914	9.75	18.28	9.61	3.56	5.00	46.20	.0107
Clark	A	1	5,106	10	Mac. 4-ft.	5,666	1916	8.00	11.71	8.54	2.80	3.82	34.87	.0062
Clay	A	5	3,500	10	Mac. 4-ft.	3,889	1915	11.10	4.08	6.27	2.08	2.86	26.39	.0068
Cook	A	32	2,623	18		5,246	1914	3.00	6.66	1.07	1.90	1.53	14.16	.0027
Cook	B	38	7,111	18		14,220	1914	8.00	19.05	2.16	10.60	4.83	44.64	.0031
Cook	C	3	24,000	18		48,000	1915	129.74	71.29	21.19	42.50	32.13	296.85	.0062
Cook	D	19	16,235	18	Earth and mac.	31,210	1915	16.00	28.01	3.05	11.60	7.12	65.78	.0021
Cook	E	29	19,443	18		38,885	1915	73.00	50.32	13.94	28.70	20.10	186.06	.0048
Crawford	A	6	2,700	15		4,500	1915	3.58	.25	2.95	.72	.91	8.41	.0019
Crawford	B	3	18,049	10	Gravel	20,054	1915	20.49	12.57	15.45	9.22	7.00	64.73	.0032
De Kalb	A	1	6,009	10		6,677	1915	12.25	7.42	.....	4.35	2.91	26.93	.0040
De Kalb	C	1	17,923	10		19,914	1915	33.50	11.02	1.34	11.60	6.99	64.45	.0032
Effingham	A	7	8,418	10		9,373	1915	21.07	8.74	2.72	2.37	4.23	39.13	.0012
Fayette	A	6	7,410	10	Mac. 4-ft.	8,233	1915	23.18	8.74	8.19	.....	4.87	44.98	.0055
Franklin	A	1 & 1a	4,378	10		4,864	1915	4.30	.58	2.04	1.44	1.03	9.39	.0019
Grundy	A	2	9,400	10	Mac. and con.	9,445	1915	.....	8.80	2.41	.....	2.37	13.58	.0014
Iroquois	A	7	22,085	10		24,539	1915	25.80	1.43	11.27	9.70	5.85	54.05	.0022
Iroquois	B	7	13,306	10		14,850	1914	17.10	1.42	11.97	7.18	4.56	42.23	.0028
Jefferson	A	3	3,822	10	Mac. 4-ft.	4,247	1915	5.60	19.16	7.55	1.08	4.14	37.53	.0088
Kane	A	1	17,665	18		35,495	1915	90.25	24.95	15.12	21.85	18.47	170.64	.0048
Kane	B	1	96	18		192	1915	.50	.67	.10	.....	.15	1.42	.0074
Kane	C	1	3,220	18		6,680	1915	1.00	.73	.65	.45	.34	3.17	.0048
Kankakee	A	1-G	9,450	10	Mac. 4-ft.	10,500	1915	18.00	12.22	.80	7.80	4.73	43.55	.0042
Kendall	A	1	8,200	15		13,667	1915	11.75	7.16	3.64	4.60	3.29	30.44	.0022
Lake	A	6	12,325	10	Mac. 4-ft.	14,589	....	31.00	7.88	2.60	9.70	6.33	57.51	.0039
La Salle	C	11	7,176	18		14,358	....	8.40	.18	2.85	2.30	1.67	15.40	.0011
Lawrence	A	5	5,680	10	Mac. 4-ft.	6,311	1915	9.00	5.97	14.56	4.05	3.95	37.53	.0060
Lee	A	5	11,310	10	Mac. 4-ft.	12,566	....	14.50	11.40	16.95	3.90	5.67	52.42	.0042
Logan	A	3	3,700	10	Mac. 4-ft.	4,111	1915	6.10	5.00	.70	2.90	1.79	16.49	.0040
Logan	D	13	3,700	10	Mac. 4-ft.	4,111	1915	10.85	7.33	4.95	6.80	3.62	33.55	.0082
McHenry	A	1	2,600	10	Mac. 4-ft.	2,889	1914	1.00	2.66	.....	1.90	.67	6.23	.0022
McHenry	B	11	1,500	10	Mac. 4-ft.	1,667	1915	.50	2.00	.....	1.90	.53	4.93	.0030
McHenry	C	11	1,080	15		1,800	1916	4.50	.....	2.12	.....	.80	7.42	.0041
Menard	A	7	2,300	10	Mac. 4-ft.	2,555	1915	21.60	2.70	4.64	1.90	3.74	34.58	.0135
Moultrie	A	5	7,100	10		7,889	1915	8.50	2.34	8.97	3.36	2.83	26.00	.0033
Peoria	A	4	6,242	10	Mac. 4-ft.	6,935	1915	.....	.....	.....	.....	.....	.....	.....
Rock Island	A	11	4,969	10		5,521	1915	8.50	13.21	.27	3.90	3.14	29.02	.0053
Sangamon	A	2	2,200	18		4,400	1915	7.25	12.43	.....	.....	2.39	22.07	.0050
Sangamon	B	3c	2,389	18		4,778	1914	7.00	2.55	.....	.....	1.16	10.71	.0022
Sangamon	C	5	2,450	18		4,900	1914	3.00	2.55	2.29	.....	.95	8.79	.0018
Sangamon	E	9	2,350	18		4,700	1914	.....	.25	.....	.....	.13	.38	.0001
Schuyler	A	5	6,700	10		7,445	1915	15.65	10.32	3.61	4.80	4.17	38.55	.0052
Tazewell	A	9a	4,280	10	Mac. 4-ft.	4,756	1914	17.25	.25	4.90	2.24	3.00	27.64	.0058
Tazewell	C	11	2,216	10	Mac. 4-ft.	2,462	1915	.....	.....	.....	.....	.....	.....	....
Tazewell	E	11	1,500	10		1,667	1915	.....	.....	.....	.....	.....	.....	.....
Whiteside	A	6	3,100	10	Mac. 4-ft.	3,444	1915	22.50	10.93	3.87	.....	4.50	41.80	.0121
Will	A	2	9,900	10	Mac. 4-ft.	11,000	1914	44.00	11.73	9.70	6.90	8.78	81.11	.0074
Will	B	13	11,150	18	Mac. 4-ft.	22,300	1915	.....	21.73	1.50	.....	2.82	26.05	.0012
Williamson	A	8	6,300	10		7,000	1915	25.46	14.83	5.33	3.60	5.97	55.19	.0079
Woodford	A	1	7,270	10	Mac. 4-ft.	8,077	1915	18.00	13.27	7.92	1.92	4.99	46.10	.0057
						Township Roads.								
De Kalb, De Kalb Twp.			5,280	12	Mac. 2-ft.	7,334	1912	12.75	4.22	.46	3.90	2.59	23.92	.0033
De Kalb, Malta Twp.			5,340	10		12,400	1914	27.50	.48	.72	3.90	3.95	36.55	.0030
Kane, Aurora Twp.			5,300	18		10,600	1915	5.00	4.40	1.65	3.90	1.81	16.76	.0016
La Salle, La Salle Twp.			4,883	18 & 20		10,663	1913	13.95	.40	3.40	4.60	2.71	25.06	.0024
La Salle, La Salle Twp.			2,374	18		4,748	1914	11.50	.20	1.80	1.90	1.87	17.27	.0036
Lawrence, Petty Twp.			7,795	10		8,661	1914	.....	7.44	.....	2.16	1.16	10.76	.0012
Morgan, R. D. No. 7			1,074	18		2,148	1913	20.50	11.12	8.95	.81	5.02	46.40	.0216

$8,000,000 for Street Paving at Baltimore, Md.—Baltimore has available for the improvement of its streets and alleys during the next few years approximately $8,000,000, available at the rate of about $2,000,000 per year. The character of the paving will be mostly sheet asphalt for the streets, and Portland cement, concrete and vitrified block for the alleys. A small amount of recut granite work will also be done. The work will be advertised for bids commencing about Jan. 15, 1917, and the contracts will range from $5,000 for alley work to $200,000 each for street work.

GRAVEL ROAD CONSTRUCTION IN IOWA.

The engineering experiment station of Iowa State College during 1916 made some studies of methods of gravel roads construction adapted to Iowa conditions. The results of these investigations are described by T. R. Agg, Professor of Highway Engineering in the October Iowa Engineer, from which the following matter is taken:

Iowa Materials.—Scattered throughout the north half of the State of Iowa there are numerous gravel deposits, some of which are of excellent quality and well graded, and that contain enough material larger than ¼-in. in size to insure a surface made up of pebbles bonded together with the finer material. In some deposits there is a considerable proportion of over-size stone, but the amount of fine material is sufficient to permit crushing the over-size and adding the crushed material to the supply of gravel. Experience in Iowa and elsewhere has shown that no material coarser than a size that will pass a 2-in. ring should be used for the wearing course in this type of construction. Experience has also shown that where the gravel contains pebbles ranging up to this maximum size it is undesirable for the gravel to contain in excess of about 50 per cent of material finer than ¼ in. Wherever the coarser gravels are utilized care should be taken to remove the over-size stone, which may be thrown aside and wasted or may be crushed and mixed with the supply of gravel. Precautions should also be taken to insure that within reasonable limits the proper amount of fine material is present.

A second class of gravels that exists in considerable quantities consists of a mixture of coarse sand and a small proportion of pebbles larger than ¼ in. in size. Many deposits contain less than 25 per cent of material coarser than the ¼-in. and most of this coarse material will pass the 1-in. screen. Where this material exists it is usually the only available supply and methods of construction must be adopted that will secure satisfactory results with a gravel of this type.

Through the central part of the State many of the so-called gravel deposits are in reality nothing more than coarse sand in which there may be 5 or 10 per cent of pebbles coarser than ¼ in. in size. These sands as a general rule contain a large percentage of particles coarser than the ⅛-in., but cannot be considered as gravels within the ordinary understanding of that term. Where this material exists as the only available supply of road building material, it is employed for a type of construction resembling sand clay and the resulting surface has the general characteristic of a high grade sand clay surface.

Most of the Iowa gravels consist of quartz sand, trap rock pebbles graded in size from whatever happens to be maximum of the particular deposit down to the fine grains that are mixed with the sand and limestone pebbles ranging in size from the minimum size of pebbles in the particular deposit down to dust. There is considerable disintegrated granite in most of the deposits and some of the pebbles are granitic. As with all pit gravels the Iowa deposits contain more or less clay and some limonite. The bonding element in the gravels are clay, limonite, trap rock dust and limestone dust, these ingredients being present in varying quantities in individual deposits.

The experiments that have been conducted seem to indicate conclusively that for the coarser gravels, it is unwise to depend upon the bonding action of clay, particularly on account of the effect of motor car traffic during the dry summer months. If these roads begin to ravel the individual stones are of such size that when once loosened the surface rapidly deteriorates and ruts and pot holes develop promiscuously throughout the length of the road. As the time passes a road constructed of this class of material will bond, due to the cementing properties of the stone dust from the trap rock and limestone particles. However, the road must be subjected to traffic for a considerable period before there is sufficient of this fine material to serve as binder and during this period the only element in the gravel that assists in maintaining the stability of the surface is the clay. There must, therefore, be some clay in these coarser gravels to serve as a temporary binder until such time as traffic produces sufficient of the stone dust. If gravel of this character contains too much clay the voids will be entirely filled with it and such dust as is formed on the surface will wash off the roads rather than into the voids.

Gravels that are deficient in coarse material contain the same bonding elements as do the coarse gravels, but on account of the deficiency in fine material, raveling is not so serious as it is on the roads constructed of coarse gravel. The individual particles are small and if they are dislodged do not particularly mar the surface. It is, therefore, permissible with these gravels to depend to a considerable extent upon the bonding effect of clay, but a larger clay content is permissible than with the coarser materials. It is probable though that even with these materials there is eventually considerable fine material ground up and worked into the surface that assists in binding the particles together so that some advantage is obtained from the cementing action of the ground-up stone particles. Where coarse sand is the only available material the percentage of limestone and trap rock particles is usually so small that no considerable bonding action results from the stone dust produced by traffic on such a surface. For this material then it is necessary to depend primarily upon the bonding properties of clay for stability and a considerable percentage of clay is necessary to produce a satisfactory surface. Such a surface is in reality a high class sand clay surface.

Methods of Construction.—Two general methods of construction have been employed; the trench method and the surface method. In the trench method of construction the road bed is prepared in the same manner as for standard macadam construction. The gravel is placed in the trench, sometimes in one layer, sometimes in two layers, is carefully spread and harrowed and opened to traffic. As the traffic uses the road the gravel will compact and the time required for the layer to be thoroughly bonded depends upon the clay content of the gravel and the character of the gravel itself.

The trench method is to be recommended, especially with materials of the character of those employed in Iowa. For a considerable period these materials will be loose and poorly bonded and unless confined between substantial earth shoulders will spread under traffic until a much greater width of roadway is covered than is necessary, with a result that the material will be too thin in the middle of the road where the greatest stability is needed. The gravels are compacted more readily when placed between shoulders than will otherwise be the case. The shoulders hold the material in place and also retain water in the layer which assists in the bonding. When the layer is finally compacted the cross section is likely to be more satisfactory when the trench method has been employed. Too much cross slope is undesirable. Unless the gravel is held in place the edges are likely to push out and the gravel will have too much cross slope. Figure 1 shows a typical cross section where the trench method is employed.

The other method widely employed in the state is the so-called surface method. The gravel is spread directly on the existing roadway and is allowed to compact under traffic as in the trench method. There being no earth shoulder at the side of the layer, it spreads laterally to a considerable extent and packs more slowly than it would if it were confined between earth shoulders. Earth roads that have been brought to the standard cross section have a crown of about 1 in. per foot and if the gravel is placed on top of the earth road without first grading off the crown, the resulting cross section will have too much cross slope. When this method is employed, the road surface should be flattened until it has but little cross slope.

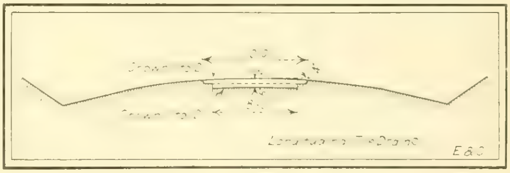


Fig. 1—Cross Section for Single Track Gravel Road.

Maintenance—Whichever type of surfacing is employed, there will a considerable period elapse before the layer becomes thoroughly bonded together and during this period the road needs constant attention to prevent it from becoming rutted and uneven. For this work the light blade grader is superior to the drag and the road should be smothered at least weekly during the first five or six weeks and then at less frequent intervals until the surface has become smooth and stable.

In some localities it has been found necessary to place the gravel in the winter or early spring and when this is done the surface method must be employed. Usually the material freezes as soon as it is placed on the road and the gravel cannot be satisfactorily smoothed. It does form a satisfactory roadway, however, except that it is likely to become very uneven. During the first summer, and preferably early in the summer, these surfaces are scarified to a depth of 3 or 4 in. and then smoothed with a blade grader and thus a satisfactory surface obtained.

The tendency of traffic on the average rural highway is to hold to the beaten track, with the result that the road eventually has two broad, shallow ruts. As time goes on these will become so deep as to hold water and when they do so the surface is likely to deteriorate rapidly. Even after the surface has become well compacted it is necessary to fill these ruts either by bringing the material from the edges by means of a blade grader or by hauling new material and depositing in the rut. This work can only be done satisfactorily when the road is soft, but even then it is desirable to run the scarifier along the rut and loosen the material before the new gravel is placed. This work needs to be done every four or five years.

On some of the more heavily traveled sections of road near moderate sized cities, attempts are being made to maintain the gravel road with oil blankets. This work is as yet in the experimental stage and while it shows some success it cannot be said that as yet a satisfactory treatment has been worked out. Probably many of these gravel roads in such localities will eventually be replaced with more durable types of wearing surface.

Conclusions.—The investigations show that very serviceable and durable roads can be constructed with Iowa gravels if suitable construction methods are employed, and that for a great percentage of the country roads this type of surface is adequate for the traffic conditions. The trench method has a great deal to recommend it and should be employed except where materials are placed on a frozen road.

The satisfaction a gravel road will give will depend to a large extent upon the faithfulness with which it is maintained, especially during the first few weeks after it has been opened for traffic.

The use of the carpet coat of oil gives promise of success, but much work will be necessary before this treatment can be developed to a state of perfection, especially for the roads constructed of gravels containing an excess of sand.

STREET FLUSHING EQUIPMENT.

The results of an extended study of street flushing methods and machinery are given by R. W. Parlin, Engineer with the New York Bureau of Municipal Research in a paper prepared for the last annual meeting of the American Society of Municipal Improvements. In his paper Mr Parlin, who, by the way, has recently been appointed Deputy Commissioner of the Street Cleaning Department of New York City, gives comparative annual and unit costs for cleaning with various types of equipment. These figures are based upon actual experience in the following cities, with equipment noted: Chicago, automobile, pressure pump; Los Angeles, Cal., automobile, pressure pump; Rochester, N. Y., automobile, pressure pump; Worcester, Mass., street car, pressure pump; Detroit, Mich., horse-drawn, pressure pump; Milwaukee, Wis., horse-drawn, pressure pump; Detroit, Mich., horse-drawn, air pressure; Washington, D. C., horse-drawn, air pressure. He concludes that the most economical examples of the various types of equipment as shown by the cost comparisons are: 1. New York, hose equipment. 2. Milwaukee, horse-drawn equipment. 3. Chicago, auto equipment. 4. Worcester, street railway equipment.

To determine the relation of these various types of equipment to each other a diagram, Fig. 1, was drawn, which shows the unit cost of cleaning various areas with the four types of equipment. The data used in constructing the diagram were based upon that obtained from the cities noted above and the assumption that the area represented the schedule area to be covered each day for 200 days.

This diagram shows that hose flushing on small areas was the most economical method; that up to 40,000 sq. yd. the horse-drawn equipment was next in economy; that from 40,000 sq. yd. to 90,000 sq. yd. the hose was about as economical as the automobile; that from 90,000 sq. yd. to 120,000 sq. yd. the automobile was supreme, and for daily schedule areas of over 120,000 sq. yd. the automobile and street car equipment give nearly the same economy.

This means, states Mr. Parlin, that small cities which do not have over 40,000 sq. yd. of hard pavement to clean each day can better afford to use hose equipment if hydrants are close enough together and plenty of water is available. If local conditions prevent the use of hose, then horse-drawn equipment is economical if only flushing is required. If both flushing on the hard pavements and sprinkling on the macadam or gravel streets is desired, the automobile appears to be by far the most economical equipment.

In large cities there appears to be no doubt that the automobile and street car equipment are the most economical, perhaps with the possible exception of those small or inaccessible areas which the larger equipment cannot reach. On such areas hose equipment can well be used as auxiliary to the machines.

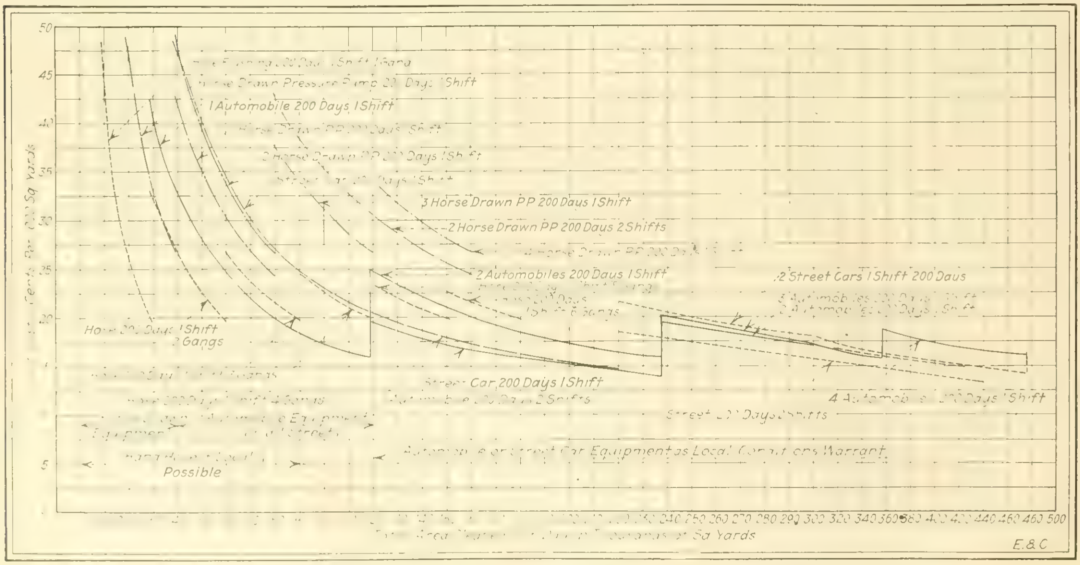


Fig. 1—Comparison of Various Types of Street Flushing Equipment.

Wherever the city has areas of more than 120,000 sq. yd. on street railway streets the street car equipment should be economical. Wherever the street car franchise provides for the sprinkling of the right of way the adoption of this type of equipment is especially to be desired, first, to eliminate sprinkling, and, second, to replace it by flushing, which is greatly to be preferred. The costs of street cleaning should be reduced, and if really effective sprinkling of the railway area has been provided the expense to the traction company should be reduced as well.

Mr. Parlin concludes that perhaps the type of street washing equipment which has most in its favor is the combination sprinkler, flusher and squeegee. With such a machine it should be possible to secure the most efficient cleaning and the greatest economy. One of the weaknesses of flushing is the necessity for leaving the dirt spread over a wide strip next to the gutter, especially on dirty smoothly paved streets which have little crown or grade. By running a squeegee along the gutter after flushing the center of the street much of this objection would be removed.

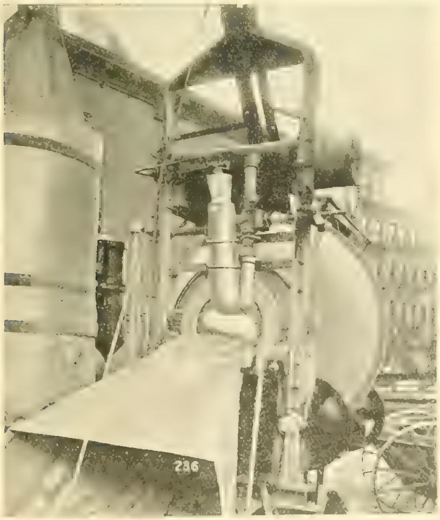
Combination equipment has been in use in Europe for several years. The first developed for use in this country is now being constructed upon designs drawn for Commissioner Fetherston of New York City. This will be of the tractor trailer type, with an 1,800-gal. tank, an electrically-driven pump and either an electrically-driven machine broom or squeegee.

HEATING CONCRETE IN THE DRUM WITH AN OIL BURNER.

The concrete heater illustrated was first designed and built early last winter at the request of several contractors engaged on the subway work in New York City. Tests conducted at that time with the apparatus are stated to have given the following results:

½ cu. yd. batch heated to 50° F. in 2 minutes
½ cu. yd. batch heated to 60° F. in 3 minutes
½ cu. yd. batch heated to 80° F. in 4 minutes

The heater uses fuel oil or kerosene and is made in two types. The compressed air type is equipped with a 25-gal. oil storage tank and air regulating valves, filling pipe with plug and full union. The approximate oil consumption is 1½ gal. per hour.



Hauck Oil Concrete Heater.

The other type of heater is designed for use where compressed air is not available. It consists of a 20-gal. oil storage tank equipped inside with a powerful hand pump. The tank can be placed on the ground or on the engineer's platform. It is necessary for operating this vaporizing type of burner to carry oil pressure from 12 to 75 lb., which is obtained from the hand pump placed inside the tank and which requires about 90 seconds of pumping to obtain the above mentioned pressure. No air from the tank necessary for vaporizing the kerosene in the burner and pressure is only used for forcing the oil to the burner. The burner is attached to a steel pipe, oval shaped at the lower end and bent so that flame shoots diagonally into the mixer. It is fastened to the mixer by an iron band and connected to the oil tank by hose or iron pipe.

The apparatus described above is known as the Hauck Oil Concrete Heater. It is made by the Hauck Manufacturing Co., 140 Livingston St., Brooklyn, N. Y.

METHODS AND COST OF MAINTAINING 30 ACRES OF PARKS AND BOULEVARDS.

Contributed by H. R. Ferris, Victoria, B. C.

The 30 acres mentioned above are made up of approximately 3½ acres in seven small parks and 26½ acres in long, narrow boulevards paralleling the pavements and intersected at frequent intervals by cross streets. The boulevards also contain many surface improvements, such as light standards, hydrants, trees, etc., which tend somewhat to increase the cost of maintenance, particularly grass cutting.

The crew employed during the summer months (May to September, inclusive), when maintenance is at its height, consists of:

Superintendent part time
One man driving horse mower—part time.
One man following horse mower.
One man general care of plants, etc.
Four to six men watering.

The superintendent makes the "rounds" of the job about three or four times daily on a motorcycle, and only that portion of his time which is actually spent on the boulevards (the superintendent has numerous other duties) is charged against this work.

The grass (26½ acres) is cut once a week with a 32-in. horse mower, this generally requiring from 30 to 34 hours, depending on the weather. The balance of the driver's time is employed in the care of tools, hose, etc., and miscellaneous odd jobs not directly connected with maintenance. It might be mentioned here that horse mowers are more economical than auto mowers, when boulevards contain numerous obstacles and are intersected by cross streets. One man with a hand mower follows the horse mower, cutting those places inaccessible to it. He also trims the grass around standards, hydrants, trees and other surface improvements as he comes to them.

The number of men engaged in watering varies somewhat, depending on the weather, but is generally five or six. They work nine hours daily, from 5 to 8 in the morning and 5 to 11 at night. Three-quarter inch hose is used and each man runs two or more lengths. A specified area is given to each workman, varying in size according to location, etc., which he is obliged to keep reasonably green. A special bonus is paid to this crew for economy in the use of water, as well as the usual bonus which is paid to all men in the employ of the company for general efficiency. Water is paid for by the company per 1,000 gal. and is metered. A careful check is kept on the consumption and any apparent waste is immediately investigated.

One man is employed full time in the care of seven small parks and two private gardens, which together comprise about 3½ acres. A little watering only is required by these grounds, which are some distance apart, or otherwise some additional help would be needed.

All fertilization, planting and repairs or renewals of grass are done during the winter months after summer maintenance is finished. Necessary weeding is done in the spring just before summer maintenance is commenced. One or two men are employed part time throughout the winter on this work.

The labor costs for the year 1916 follow:

LABOR COST OF MAINTAINING 30 ACRES OF PARKS AND BOULEVARDS.

Month	Total cost	Per acre	Remarks
January	$[illegible]	$[illegible]	Snow on ground
February	[illegible]	.73	Snow on ground
March	64.00	2.13	No snow.
April	[illegible]	6.82	
May	[illegible]	11.01	Rain a little on [illegible] days
June	[illegible]	11.86	Rain a little on 8 days
July	[illegible]	[illegible]	Rain a little on 10 days
August	[illegible]	[illegible]	No rain fell
September	205.00	6.84	Rain fell on 5 days.
October	75.00	2.50	
November	70.00	2.33	
*December	65.00	2.17	
Total	$2,297.30	$76.37	

*Estimated.

The above costs are based on assumed wages: Superintendent, 50 ct. per hour; driver of horse mower, 30 ct. per hour; other labor, 25 ct. per hour. Labor costs will vary considerably according to weather, quantity of weeding done, and also according as to whether the boulevards were originally well or badly constructed, and their situation. The 30 acres mentioned above, however, were well made in the first place and well maintained from the first.

The costs are considered low, but the company has an unusual advantage, inasmuch as it is in a position to furnish other work for the boulevard crew when maintenance work is slack, thus enabling it to hold an old and organized crew. Otherwise the costs would undoubtedly be higher. The labor as given above works out to less than two-tenths of a cent per square foot per year. Including overhead, office proportional charge, depreciation, etc., the costs are about two-fifths of a cent per square foot per year.

BLANK CO., LTD.
BOULEVARD MAINTENANCE
Daily Report

Date, 7 1 1916
Trans. by H. C., 7/2/16

Hours Worked @						Description of Work	W.O. No.	Charge	
	45c	30	25					Departm't	Amt.
	1					Superintendence		Boul. Main.	.45
		1				Sharpen horse mower blades		"	.30
			2			Trim grass around standards, etc		"	.50
			5			Hand mower, cut grass		"	1.25
			40			Watering boulevards		"	10.00
		7				Horse mower on Smith & Alder Sts.		"	2.10
T'l	1	8	47			Both sides			14.60

REMARKS. 7 men engaged on boulevard maintenance today
No materials used
Water consumption normal.

Signed .... Supt.
(Over—Materials on back)

Sample No. 1—Daily Report for Superintendent.

This summer has been a wet season for this climate. The frequency of rains rather than the total quantity in summer affects the cost of labor watering, as well as the quantity used. A hard rain lasting a few hours only is not as valuable as the same rainfall in two showers a few days apart.

The water consumption from May to September, inclusive, follows:

WATER CONSUMPTION FOR 27 ACRES

Month.	Consumption, Imp. gal.	Precipitation
May	385,000	.89
June	860,000	.52
July	350,000	1.23
*August	890,000	Trace only
*September	300,000	.35
Total	2,785,000	

*August was a hot, dry month, September was a cool month

SUMMARY OF DAILY REPORT FOR PARKS

Cost for Month Ending................Cards......Card No......

Maintenance W. O. No. Location

Date	Tool Acct.						Miscel.		REMARKS
	Hrs.	Cost	Hrs.	Cost	Hrs.	Cost	Hrs.	Cost	

Above Sheet Checked by . Date . Remarks ....
Approved by Date
(Over—Materials on other side)

Sample No. 2—Bi-monthly Summary of Daily Costs. (Actual size of blank, 5 in. by 8 in.)

The water used is very carefully controlled. The meters are read at least once a day during the watering season and sometimes oftener. A graphic chart is kept in the office which shows at a glance the daily relative consumption.

The rainfall, of course, causes great variation in the consumption, as does also soil, drainage, locality and numerous other less important conditions. It may again be emphasized that money economically spent in making the boulevards right in the first place brings in good returns later on in the saving effected on both labor and water.

Two printed forms are used for segregating daily labor costs. "Sample No. 1" is the daily report which the superintendent fills in each day. Each workman also turns in a signed slip giving the number of hours he has worked, as well as the exact locality and character of the work. "Sample No. 2" is a bi-monthly summary of the daily costs. A district map of the boulevards is kept in the superintendent's office which shows areas, etc., etc., and the unit costs for the day or half month can readily be taken out by reference to the map and reports. Grass seed, plants, etc., are delivered on requisitions signed by the superintendent and waste checked by comparison of the amounts issued with the areas covered.

SUGGESTIONS ON MAINTAINING CONCRETE ROADS AND STREETS.

The Portland Cement Association has issued recently a circular containing the following suggestions for the maintenance of concrete roads and streets:

Maintenance should be systematic and imperfections given immediate attention.

Cracks.—Cracks in concrete roads occasion no inconvenience whatever to traffic, and traffic will not injure the road at such a place if the crack is filled with tar and covered with sand. The crack should first be cleaned with a stiff wire broom and all loose particles of material removed. If the crack is too narrow to permit cleaning in this manner it may be cleaned with an air jet from an automobile pump. Tar should then be poured into the crack in sufficient quantity just to flush over the edges and afterwards covered with coarse, dry sand.

Tar.—Refined coal tar should be used, having a melting point (½-in. cube method in water) of about 100° F. The tar should be heated from 225 to 250° at the time of application and may be applied by means of a sprinkling can with spray nozzle removed. Sand or screenings, thoroughly dried, graded from ⅛ to ¼ in., should be spread over the surface before the tar has cooled.

Small Holes.—Where a small hole occurs, due to the displacement of a lump of clay or a piece of coal or wood, it should be thoroughly cleaned and filled with tar and stone chips. If the hole is 2 or 3 in. in size it should first be wiped with the tar and stone chips put in; these are covered with more tar and tamped into place.

Slight Depressions.—If for any cause the surface of the concrete has scaled and a slight depression formed it can be coated with tar, stone chips added, these in turn covered with tar, and the whole covered with sand and tamped into place.

Deep Holes.—If through neglect or other causes a hole of any considerable size and depth has formed in the surface of a concrete road the concrete surrounding the edge should be cut away until the walls are made practically vertical and cut to a depth of at least 3 in., or as much deeper as the hole may be. The hole should then be filled with water and stand for a few hours, after which the water should be removed, the sides washed with cement paste and the hole filled with concrete of as nearly the same materials and mixture as that in the original road. The surface should be finished with a wood float and brought to a true shape with the surrounding surface of the concrete, then covered so as to protect it from traffic. This may be done by the use of steel plates or pieces of plank, which should in turn be covered with moist earth or gravel. This will permit traffic to use the repaired portion of the road without injuring the concrete. On a wide street where there is sufficient room a barrel could be placed over the hole and traffic diverted around it.

If it is necessary to cut a hole through the entire thickness of the concrete slab gravel should be placed in the sub-base and thoroughly rammed, so as to form a compacted base on which the new concrete will rest. Where water has been allowed to stand in such a place it should be compacted after the water has been removed and just before laying the concrete.

The consistency of the concrete should be sufficiently stiff to require considerable tamping to bring water to the surface, so that it may be possible to ram it thoroughly into place.

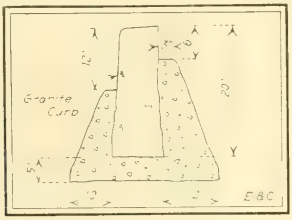
A new patch should be kept moist for at least 4 or 5 days and protected from traffic at least 10 days.

LABOR COSTS OF LAYING CURVED GRANITE CURBS AT STREET INTERSECTIONS.

Contributed by H. R. Ferris.

The following costs cover the labor of laying 44 returns (630 lin. ft.) of curved granite curb at 11 street intersections. The stones were 20 in. deep, 6 in. wide at top and dressed for 5 in. on the face. At the bottom they were generally 7 or 8 in. wide. Each piece came in lengths varying from 4 to 7 ft. and were conveniently delivered within a few feet of their final location. The bottom 12 in. of the curb were imbedded in 1:3:6 concrete. (See sketch.)

The work was done by an energetic and competent curb-setter and helper who handled their part of the work well. The common labor, which included the excavation of the trench, moving stones, mixing concrete, etc., was very inefficient, however, and probably 35 per cent of this cost could have been saved with first class laborers.



Cross Section of Curb.

The curbs were laid under strict inspection. No joints over ¼ in. were allowed, and the bottom of all curbs had a true setting bed in order to "secure a uniform depth throughout." The workmen were required to set the stones so that they would be "free of depressions and wind, and true to line and grade." The stones were set to a 9-ft. radius.

The labor costs follow:

Cost of Laying 630 Lin. Ft. of Curved Granite Curb.

Curb setter, 84 hours @ 40c	$ 33.60
Helper, 56 hours @ 35c	19.60
Labor, 342 hours @ 25c	85.50
	$138.70
Total cost per lin. ft. of labor	22 cents

POROUS TILE IN SUB-SURFACE DRAINAGE.

A 6-in. porus tile underdrain was used with success in intercepting the water for draining a short section of concrete road. The work is described by W. F. Childs, Jr., in the Cornell Civil Engineer. By opening a system of holes the direction of seepage was ascertained. A ditch 1 ft. wide on bottom and 18 in. below subgrade was then opened at a distance of 19 ft. from center line of road and running parallel with same to a natural outlet. On the bottom of the ditch was laid a shallow depth of straw and the porous tile laid directly upon the straw. On the top of the tile were laid longitudinal strips of 2-ply tar paper 12 in. wide, joints overlapping 4 in. and the pipe covered with the clayey material excavated from the ditch. There were some 400 lin. ft. of this tile laid at a cost of less than 8 ct. per foot in place, including excavation, straw, tile, tar paper and labor back-filling and laying tile. Previous to the laying of this tile the shoulder of road was always soft and mucky and water always stood along edge of concrete which had begun to show disintegration. Since this tile was laid no further trouble has been experienced. Mr. Childs believes that very good results can be obtained by use of porous tile in sub-surface drainage and that very often the glazed tile with bell joints is used at a much greater cost when the ordinary farm tile would have answered the same purpose. Conditions being the same the life of the glazed tile is somewhat longer than that of the porous tile, but the cheaper first cost of the latter will more than offset the difference in serviceability of the two.

EXPERIMENTAL OIL-LIMESTONE AND SAND ASPHALT ROAD CONSTRUCTED AT OCALA, FLA.

Among the road materials locally available in Marion County, Florida, are sand clay, a fairly well graded sand, and easily crumbled oolitic limestone, which hardens somewhat on exposure to the air. During the season of 1915 the U. S. Office of Public Roads constructed an experimental section of highways, using the last two mentioned materials with bituminous materials. The work is described in a professional paper issued Nov. 10.

The series was installed in the spring of 1915 on the Ocala-Blichton road, about 3½ miles west of Ocala. Limestone for the oil-limestone experiment was obtained from a deposit which outcropped about 1 mile from the road. It was quarried with the use of dynamite and heavy sledges and in this way was easily broken to the desired size. For the surface course of the oil-limestone experiment the limestone was screened at the quarry over a ½-in. screen, yielding approximately 50 per cent retained on a ½-in. screen and passing a 3-in. screen. A suitable quality of sand for the sand-asphalt experiment was located about 2/5 mile from the road.

The equipment consisted of 2 sirup-heating kettles of 200 and 80 gal. capacity, which were set in a stone furnace and heated with wood fuel; a concrete mixer equipped with revolving blades and operated by a 4-h.p. gasoline motor; dump wagons; a 6-ton steam tandem roller; 2 hand rollers; corrugated culvert pipe for heating sand; hand pouring pots, and hand tools.

Limestone, Residual Asphaltic Petroleum, Penetration Method.

This section had a length of 1,777 ft. and an area of 1,834 sq. yd. Upon the rolled subgrade, partly of sand-clay and partly of sand, a foundation course of pit-run limestone was spread and rolled until firm. The depth of the foundation course was 5 in., loose measurement. Upon this a wearing course, 2 in. thick by loose measurement of screened rock was spread and rolled with the 6-ton tandem roller sufficiently to smooth and shape the course but not to break up the fragments. Upon the wearing course was applied approximately 1 gal. per square yard of the residual asphaltic petroleum, analysis of which is given in Table 2. The petroleum was heated in the large sirup kettle at the roadside and was spread by means of hand-pouring pots. In applying the hot oil care was taken to coat the rock as uniformly and completely as was possible. The oil was immediately covered with sand and the surface was then rolled until firm. As the oil was forced upward through the sand by rolling, more sand was distributed to absorb it. Shoulders, 2 ft. wide and 6 in. thick, of pit-run rock or screenings, were constructed on each side of the 14-ft. oil-treated road. Materials and cost data for this experiment are given in Table IV.

TABLE 2.—ANALYSIS OF RESIDUAL ASPHALTIC PETROLEUM USED IN EXPERIMENT NO. 1.

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	1' 48"
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible] naphtha	[illegible]
[illegible] per cent	[illegible]
[illegible] per cent	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Total, per cent	100.00

[illegible]

Sand-Oil Asphalt.

This section was 793 ft. in length and 1,233.56 sq. yd. in area. The subgrade on the east end of this experiment, from station 212+92 to station 217+30, was an old sand-clay road, and in general provided a firm foundation. On this section the subgrade was dressed and rolled and the sand-asphalt mixture laid 2½ in. thick after compression. The subgrade from station 217+30 to station 220+85 consisted of fine sand, and the wearing course in this section is 3½ in. thick, laid in one course from station 217+30 to station 219+00, and in two courses, each roughly 1¾ in. thick, from station 219+00 to station 220+85. Difficulty in securing a satisfactory bond between the two courses was experienced, owing to the fine sand distributed over the surface by laborers who walked over the first course. The sand subgrade was rolled with the 6-ton tandem roller, but as this left it much rougher than desired it was smoothed with hand rollers immediately in advance of spreading the mixture.

The heating and mixing operations were carried on about 2/5 mile from the road, where a clean, well-graded sand was found in abundance. All the sand was screened to remove twigs and roots, and also to reduce it to a finely divided condition, which undoubtedly facilitated heating. It was piled over 15-in. corrugated culvert pipes for heating, and stirred occasionally. This method of heating was found to be costly and relatively inefficient, and lack of heated sand limited the daily output of the mixer to much less than half of its normal capacity. The mixer, which was provided with revolving blades, was operated by a 4-H.P. gasoline motor, and was placed on an elevated platform, so that it could be emptied directly into a chute above the wagons. For each batch 6 cu. ft. of heated sand was carried from the heating pipes to the charging platform in wheelbarrows, each carrying 2 cu. ft. After stirring the sand to avoid local overheating, oil-asphalt represented by the analysis given in Table II was added in an amount equal to about 10 per cent of the total weight, and the mixing was continued until all particles were thoroughly and uniformly coated with bitumen. The hot mixture was hauled to the road and, from dumping boards laid on the shoulder, was spread with shovels and hot rakes to the required thickness. The forms consisted of timbers placed along each side of the road at the proper grade. As soon as spread, the mix was rolled longitudinally and transversely with hand rollers, and after standing for some time, was covered with a light application of Portland cement, and rolled with the 6-ton tandem roller. The timbers were then removed and limestone shoulders, 6 in. thick and 2 ft. wide, compacted by rolling, were constructed to support the sand-asphalt surface. Table III gives typical analyses of the sand-asphalt mixture. The data relating to materials and cost, given in Table I, do not differentiate between the various sections, but are presented just as if the cost were uniform over the entire experiment, irrespective of the varying thickness of the wearing surface.

TABLE III.—ANALYSIS OF OIL-ASPHALT[1] USED IN EXPERIMENT NO. 2.

Specific gravity 25°/25° C.	1.041
Melting point °C	64
Penetration, 25° C., 100 grams, 5 seconds	50
Loss, 5 hours, 163° C., 20 grams, per cent	0.06
Penetration of residue[1] as above	38
Per cent of total bitumen insoluble in 86° B. naphtha	29.45
Fixed carbon, per cent	17.50
Soluble in CS_2 (total bitumen), per cent	99.86
Organic matter insoluble, per cent	.10
Inorganic matter insoluble, per cent	.04
Total, per cent	100.00

[1] Hard, sticky, glossy, semi-solid.

TABLE IV.—TYPICAL ANALYSES OF SAND-ASPHALT MIXTURES USED IN EXPERIMENT NO. 2.

	I. Per cent.	II. Per cent	III. Per cent	IV. Per cent	V. Per cent
Bitumen soluble in CS_2	8.41	8.27	9.87	8.16	10.28
Mineral aggregate					
Retained on 10-mesh sieve	0.1	0.0	0.1	0.0	0.1
Passing 10-mesh sieve, retained on 20-mesh sieve	1.6	2.5	1.4	1.1	1.5
Passing 20-mesh sieve, retained on 30-mesh sieve	4.9	4.7	5.1	4.7	4.3
Passing 30-mesh sieve, retained on 40-mesh sieve	10.8	10.4	10.9	9.1	7.1
Passing 40-mesh sieve, retained on 50-mesh sieve	13.1	12.3	13.5	13.7	16.0
Passing 50-mesh sieve, retained on 80-mesh sieve	31.7	32.3	33.3	33.0	33.4
Passing 80-mesh sieve, retained on 100-mesh sieve	12.9	11.8	12.5	12.1	12.4
Passing 100-mesh sieve, retained on 200-mesh sieve	15.7	19.7	14.2	12.0	18.4
Passing 200-mesh sieve	9.2	7.2	9.0	14.0	6.9
Average percentage of bitumen (soluble in CS_2)	.	9.25	..	....	....

The cost data given in Tables V and VI are based on the following scale of wages and unit prices:

Foreman, per 10-hour day	$3.25
Sub-foreman, per 10-hour day	1.25
Skilled labor, per 10-hour day	1.75
Common labor, per 10-hour day	1.00
Teams, per 10-hour day	3.00
Asphaltic oil, f. o. b. Baltimore, Md., per gallon	0.06
Oil-asphalt, f. o. b. Baltimore, Md., per ton	12.50
Freight on oil-asphalt, Baltimore, Md., to Ocala, Fla., per ton	6.72

TABLE V.—COST DATA, BITUMINOUS LIMESTONE.

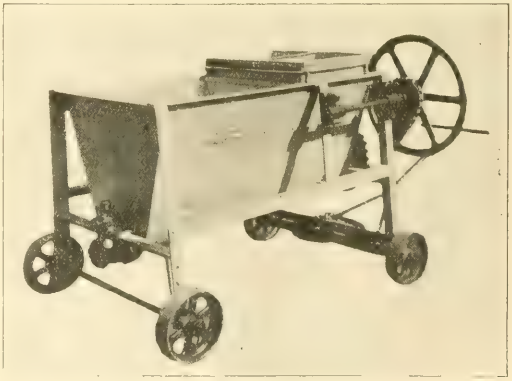
Item.	Total cost.	Cost per square yard of surface.
Rough grading	$ 45.15	$0.0247
Subgrade	48.82	0266
Shoulders	77.84	.0424
Quarrying, labor	86.84	.0472
Quarrying, explosives	51.31	.0280
Loading and hauling	179.80	.0980
Spreading base course	10.00	.0055
Screening limestone for wearing course	42.05	.0230
Spreading wearing course	8.65	.0047
Asphaltic oil, 1,801 gallons, f. o. b. Baltimore, Md.	108.06	.059
Freight on oil	57.44	.0313
Hauling oil to road	8.80	.0048
Heating and applying oil	24.52	.0133
Hauling, screening, and spreading sand	8.80	.0048
Rolling (including cost of coal)	47.56	.0258
Incidentals and supervision	52.41	.0286
Total cost	$858.05	$0.1674
Total (exclusive of shoulders)	780.21	.425

TABLE VI.—COST DATA, SAND-ASPHALT.

Item.	Total cost.	Cost per square yard of surface.
Rough grading	$ 34.80	$0.0282
Subgrade	25.01	.0203
Shoulders	119.60	.0969
Asphalt, 21.77 tons, including freight	418.70	.3393
Hauling asphalt (3¼ miles)	14.77	.0120
Screening and heating sand	310.00	.2512
Heating asphalt	67.02	.0543
Mixing sand and asphalt	192.09	.1557
Transporting mixture	70.30	.0570
Spreading mixture	39.56	.0320
Hand rolling	5.45	.0044
Power rolling	20.75	.0168
Total cost	$1,318.05	$1.0681
Total (exclusive of shoulders)	1,198.45	.9712
Total (exclusive of rough grading and shoulders)	1,163.65	.9430

PAVING GROUT MIXER.

The accompanying illustration shows a grout mixing machine designed by A. W. D. Hall, City Engineer of Jackson, Mich., which has been used very successfully on many thousand yards of pavement. It is claimed that this machine will mix and deposit on the pavement a perfectly mixed grout filler at a less cost than can be obtained by the usual method of hand mixing for large work. The grouter weighs 640 lb. and is 4 ft. long and 26 in. wide. The capacity of each hopper is 1 cu. ft. The machine shown is operated by a crank and a flywheel, but Mr. Hall recommends that a 1½-HP. gasoline engine be used for power. It is stated that a batch of 1 cu. ft. of sand and 1 cu. ft. of cement can be mixed by the first method in 2 minutes or less. If the gasoline engine is used the time is reduced to 30 to 40 seconds.



Hall Paving Grout Mixer.

A 24-hour traffic count shows that 804,146 persons used the East River bridges at New York City on the day in question.

FUNDAMENTAL CONSIDERATIONS IN THE MAKING OF PLATS.*

The general principles to be followed in developing a proper street plan have been laid down by Professor Unwin as follows:

> Having settled the purpose of the different areas, determined the general character of growth and the approximate direction desirable for main and subsidiary highways, the town planner finds himself with the following component parts out of which to make his design, namely: The main center-point, or climax, dominating the whole; the secondary centers in definite proportion and relation to it; and the main highways linking them up; the whole giving the bones or main framework of the design.
>
> Within the space defined by this framework, having special relation to the secondary centers and proportion to the primary highways, we have the network of secondary highways; while within the areas which these leave, for the purpose almost solely of giving access to the buildings we have the minor roadways or drives, which should be in relation to any subsidiary center-point, and both in relation and proportion to the framework of secondary highways. No system cuts up the land into more awkward corners or more thoroughly destroys the street facades than that which consists of a framework of diagonal highways laid upon a rigid gridiron system of minor roads, and from no system do such unsatisfactory road junctions result. In town planning it is essential to avoid being carried away by the mere pattern of lines on paper. Order, definiteness of design there must be, but there must first be grasped an understanding of the points where order is important and will tell, and of those where it matters little.

These principles may perhaps be restated as follows: In every city there is a central business area to and from which the greatest amount of traffic flows. There are, in addition to this central area, subsidiary centers of activity, either business, social, educational or residence. Each of these subsidiary centers should be connected by direct routes having easy gradients with the central portion of the city. It is not necessary, in fact it is not even desirable, that these routes should be straight, but they should be conditioned by the topography and by existing improvements. The subsidiary centers should also have direct means of communication with each other. After these main lines of travel have been laid own, secondary lines may be developed also in conformity with topographical and other conditions. This will leave, then, certain areas of larger or smaller extent to be subdivided into tracts by means of purely local streets. Now it is not at all important—in fact, it is extremely undesirable—that these local streets should all follow the main points of the compass. The systematic division of our country into townships and sections has been a great convenience in many respects, but it is carrying the influence of the section line entirely too far to make it—as has been done so universally throughout the western state—the basis of all street planning work. Each tract of land into which the primary and secondary system of streets divides should be platted solely with a view to its own special requirements, with such orientation of blocks and arrangement of streets as will serve to develop to the best advantages its own individual peculiarities. It is by no means important that these local streets should be continuous, in fact it will add very much to the beauty and detract nothing from the utility of the district if these streets are not continuous, but are so arranged as to furnish desirable building sites, closing the vista at convenient points. By following this plan the sharply angular lots involved in the diagonal street laid across the rectangular street plan will be very largely avoided. Each tract will have a character and an attractiveness of its own and the city will be free from the curse of dull uniformity.

The platting of any district should, of course, be varied to meet the topographical conditions. In some cases, for instance, we have steep hillsides. The folly of platting such hillsides in the regulation way into blocks consisting of two tiers of lots separated by an alley or sometimes by no alley at all, is apparent. In grading the streets laid out in this manner there will necessarily be heavy cuts on one side and heavy fills on the other. The cost of grading is therefore enhanced, as is also the cost of adjusting the property to private use. In such cases it is very much better if narrower and more frequent streets should be platted, so adjusted as to give reasonably good gradients and easy access to the property; these streets to be separated by a single tier of lots. These lots might be a little longer than the ordinary lot. The property then has the advantage of permitting all of the residences to be so situated that they have an outlook away from the hill instead of having half of them face into the hill. Furthermore, they will have access both from the rear and in front, which is a great convenience under these conditions. Where the ground is more uniform the ordinary plan of platting may be followed, but even here the exercise of a little ingenuity will yield very desirable results. It is not at all necessary that even on flat lands all blocks and lots should have uniform dimensions. This was the case in New York City, the lots all being 20 to 25 by 100 ft., and if you wish to build a church or a factory, a house or an office building, you have no choice as to dimensions except to take as many lots as may give the needed frontage.

Authority, therefore, should be vested in the city to regulate not only the size and location of streets dedicated to public use, but the size of the lots themselves. We are all familiar with the fact that the farther the lots are situated from the center of the city and the cheaper the land the smaller the lot becomes. Public interest and convenience require that there should be public control over this feature of platting.

Then, too, it has sometimes been the custom when plats fail to receive the approval of city authorities that the owner proceeds to sell the lots off by metes and bounds descriptions, without regard to the public interest. The law should provide a certain subdivision of a section or a minimum size and prohibit the sale of smaller tracts unless a proper plat had previously been duly prepared and filed for record. In the making of any plat it must be borne in mind constantly that the present use of the property may—undoubtedly will in many instances—be greatly modified as time goes on. In so far as possible such future use should be anticipated and the plat adapted to such changing use as nearly as may be. This changing use of property, due, of course, to the fact that a city is a living, growing organism and not a dead piece of mechanism, constitutes one of the chief difficulties of city planning. The erection of garden cities, with every detail ordered beforehand, seeks to eliminate this difficulty by fixing the maximum limits of the future city. It is better from this point of view to build a new city than to permit the old one to grow beyond its boundaries.

It is important that alleys should be required in all blocks platted on reasonably level ground. Such alleys will have a use even when the property is used solely for residence purposes, in that they permit the construction of garages in the rear of the property. Later on, as the use of the property becomes more intensive and as it becomes occupied by large buildings, these alleys become more and more useful for the service of such buildings, relieving the street from the more objectionable and unsightly necessities of such service, such as, for instance, the collection of garbage.

In all modern street planning, we must necessarily take into consideration the immense change in traffic conditions which is taking place. The motor bus is rapidly replacing the street car. The number of passengers carried by street cars in London in 1914 showed practically no increase over those carried in 1911. For the same period, however, passengers carried by motor busses showed an increase of about 60 per cent. It is true, of course, that London is not so adequately supplied with street cars as some American cities. However, the great convenience and flexibility of motor bus transportation will inevitably increase its use in our cities regardless of the ficilities afforded by street car systems. The effect of this development upon the street system should be carefully considered by municipal engineers. When this traffic is properly controlled by the municipality—and it is as much the function of the municipality to supply adequate means of transportation as it is to provide an abundant supply of water or electric energy—it may be that the tendency to congestion of travel on certain streets will be reduced because it will be possible to occupy more streets with lines of bus transportation than it was possible to occupy with street cars. This will have a tendency to scatter this traffic and to utilize more fully the street system. On the other hand the great increase of motor-driven vehicles has led to an enormous increase in street traffic. The streets in any city which a few years ago were suburban in their character now carry heavy traffic. There are some thoroughfares towards which, on account of their location, traffic tends to flow in vast quantity. The planning of streets so to care for this increasing traffic will probably call for increasing widths, not only of the main thoroughfares but of many secondary streets as well. The Royal Commission on London Traffic recommended that the principal arterial highways be 140 ft. in width and that the streets be graded down to a minimum of 40 ft. In my judgment, no street should be less than 60 ft. in width except where situated on steel sidehills or where it will manifestly have nothing more than purely local use. The question as to the width of a street opens up, of course, an interesting and essential feature in city platting.

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*From a paper by Arthur H. Dimock, City Engineer of Seattle Wash., presented at the 7th Annual Convention of the League of Washington Municipalities.

It is now recognized that the greatest municipal mistake of the 19th century was the failure to control the development of suburban areas. One of the marked features of the last century was the tremendous growth of cities—a growth fostered and made possible by modern developments and methods of transportation and intercommunication. There is little doubt that this remarkable growth will continue for many years to come. The modern city is beginning to lose its squalor and unattractiveness and is becoming the most healthy and most desirable spot on earth in which to live. For this and many other reasons, the continued rapid growth of cities is assured. The development of cities, however, will not be confined to the great centers of population. All cities at all favorably situated will continue to grow. This is especially true on the Pacific Coast, the development of which is yet in its infancy. It is important, therefore, that not only our larger cities, but that the smaller communities of this state, shall embrace every opportunity to lay out systematically and with foresight as may be possible the territory which they will some day occupy. All of our cities and towns will from time to time extend their boundaries and add new territory. This territory will usually be already platted and its future fixed. Too often this platting will have been done without reference to the needs of the future city and without any consultation whatever with the city authorities. Now in order to secure the proper development of this suburban territory—that is to say of areas outside the present official boundaries of our towns and cities—it is essential that the control of the platting and laying out thereof be vested in some authority in which the city would have, if not the paramount, at least an equal, voice. In providing for this control of the development of suburban areas, it will frequently happen that other municipalities are included in the district tributary to some growing city. It will be necessary, of course, to consider the rights and privileges of such municipalities. We should not, however, lose sight for one moment of the fact that the public interest and convenience of the whole community and not of any part thereof should be the controlling factor in these decisions. The law might require, for instance, that cities should have the power to create a zone outside of the existing boundaries, in which zone they should have a voice in the development and platting of the streets. All plats within this zone prior to approval by the legislative body vested with this authority should bear the approval of a commission composed of the county engineer, the city engineer and possibly a state officer, say, for instance, the professor of municipal engineering at the state university. Or the law might provide that plats within such district or zone should not become effective until approved by some state officer, as for instance the State Commissioner of Public Lands. Or possibly this approval by a state official might not be required except in cases of inability to agree between the county and city authorities. Another method would be the creation of town planning commissions with power to lay out all such lands and to require all plats to conform thereto. These suggestions are purely tentative, but I am sure that the problem is one of great importance to all of our cities, both great and small.

Another power which the city should have is that of compulsory replatting. In many of our cities areas were platted many years ago when the country was covered with thick timber or sage-brush and no one except a few prophetic souls realized that it would one day be covered with a dense population. These plats were often laid out entirely on paper in accordance with the controlling section lines. No regard was paid to hills or valleys or any other features of topography. They were laid out in many instances by real estate promoters interested solely in securing the greatest possible number of lots per acre. The real estate promoter of the type so familiar to our western cities has been the curse of modern city development.

COST OF SHEET ASPHALT PAVEMENT AT MONTREAL, QUE.

The introduction of a cost keeping system and the consequent better method of handling construction has resulted in a marked reduction in the cost of sheet asphalt pavement in the city of Montreal, Que. In 1914 the total cost of this pavement was $2.79 per square yard. In 1915 it was $2.13, a reduction of 23.6 per cent over the cost of the previous year, and in 1916 it was $1.93. The pavement consists of a 6-in. 1:3:6 concrete base, a 1-in. binder and a 2-in. wearing surface. The city has the following asphalt plants:

Division.	Plant Built. Year.	Daily Capacity. Yds.	Cost.
East	1903	1,000	$16,000
West	1909	1,500	22,000
North	1914	2,000	28,000
Portable	1914	1,500	26,000

During 1915, 600,000 sq. yd. of sheet asphalt pavement were laid. The detailed cost of the work, according to a paper presented at the last annual convention of the American Society of Municipal Improvement by Paul E. Mercier, Chief Engineer of the city, was as follows:

	Per Cent of Total.	Per Sq. Yd., Cts.
GRADING.		
Foremen	1,115	2.4327
Timekeepers	.065	.1416
Engineers	.073	.1590
Layers	.022	.0477
Drillers	.032	.0689
Water boys	.034	.0742
Watchmen	.903	1.9186
Laborers	12.693	26.9240
Teamsters	8.273	17.5536
Material	......	......
Sundries	.192	0.4081
Repairs, Int., etc.	1.551	3.2913
	24,983	52.9947
FOUNDATION.		
Foremen	.768	1.6340
Timekeepers	.053	.1140
Engineers	.308	.6555
Layers	.013	.0285
Watchmen	.894	1.9000
Laborers	5.482	11.6565
Teamsters	6.171	13.1195
Autos	.018	.0380
Stone	7.659	16.2830
Sand	7.083	15.0575
Cement	13,092	27.8350
Sundries	1.068	2.2705
Repairs, Int., etc.	2.073	4.8080
	44.682	95.4130
SURFACE.		
Foremen	.286	.5873
Timekeepers	.051	.1097
Engineers	.302	.6454
Spreaders	.670	1.4263
Tampers	.375	.8003
Watchmen	.193	.4131
Laborers	1.359	2.8913
Teamsters	.333	.7099
Autos	.604	1.2849
Material	......	......
Asp. bin. and wear	24.543	52.2193
Sundries	.696	1.4844
Repairs, etc.	.933	1.9878
	30.336	64.4754

	Grading. Per sq. yd., ct.	Foundation. Per sq. yd., ct.	Surface. Per sq. yd., ct.	Total. Per sq. yd., ct.
Labor	49.2953	29.1590	8.7839	87.2382
Material	.....	59.1755	52.2193	111.3948
Sundries	3.6994	7.0785	3.4722	14.2501
Total	52.9947	95.4130	64.4754	212.8831

The cost of material and the wages in 1915 were as follows:

Bitumen—$14.25 per ton f. o. b. plant.
Sand—75 to 98 ct. per ton f. o. b. plant.
Stone—$1.10 to $1.70 per ton f. o. b. plant or works.
Stone dust—$5.45 per ton f. o. b. plant.
Flux—10¾ ct. per imperial gallon.
Cement—$1.71 per barrel f. o. b. plant or works.
Laborers—25 ct. per hour.
Teamsters—60 ct. per hour.

As noted previously, the unit cost of the sheet asphalt laid in 1916 was $1.93 per square yard. In further detail the cost was—

	Grading. Per sq. yd., ct.	Foundation. Per sq. yd., ct.	Surface. Per sq. yd., ct.	Total. Per sq. yd., ct.
Labor	32.8257	26.9681	12.8364	72.6302
Material	.6571	50.3405	60.6638	111.6614
Sundries	3.8084	3.7504	1.4692	9.0280
Total	37.2912	81.0590	74.9694	193.3196

The cost of material and wages for 1916 was as follows:

Bitumen—$19.33 f. o. b. plant.
Sand—75 ct. to $1.10 f. o. b. cars or wharf.
Stone—$1.00 to $1.40 f. o. b. plant or works.
Stone dust—$4.90 f. o. b. plant.
Flax—10¼ ct. f. o. b. plant per imperial gallon.
Cement—$1.76 f. o. b. plant or works per barrel.
Laborers—25 ct. per hour.
Teamsters—60 ct. per hour.

PAVING EQUIPMENT FOR CUBA.

One of the largest single shipments of paving equipment on record is that just made to Torrance & Portal of Havana, Cuba, who have secured extensive paving contracts in Havana and Cienfuegos.

The shipment made by the Iroquois Works of the Barber Asphalt Paving Co. consisted of 6 cars routed by way of Key West, Fla., carrying two 3-unit asphalt plants, two 2,000-gal. and one 1,000-gal. steam heated melting kettles, 4 tandem rollers, 2 portable boilers and engines, fire wagons, paving tools, etc.

Part of 6-Car Train Load of Asphalt Paving Equipment.

Contracts already secured by the Havana firm for paving in which Trinidad lake asphalt will be used, total about 400,000 sq. yd. One of the Iroquois plants is to be located at Havana and the other at Cienfuegos.

COST OF HAULING AND SPREADING GRAVEL WITH MOTOR TRUCKS.

Montgomery County, Alabama, as noted in our Sept. 6 issue, is maintaining its 450-mile gravel road system at a remarkably low cost. In this work the county is using motor trucks, trailers and road graders. The outfit consists of six 5-ton, 6-cylinder White trucks, Troy reversible trailers and a fleet of Road King, Russell, Western and Ohio reversible road graders. Our Sept. 6 issue contained data on the reshaping and scarifying of the roads. In this issue we give some data on the hauling and spreading of gravel. This information is taken from the recently published Good Roads Book of the White Co. of Cleveland, O. This book, by the way, contains information and cost data on practically every phase of motor truck operation in the highway field. The figures quoted are those furnished by Thomas H. Edwards, County Engineer.

In hauling and spreading gravel, each truck hauls two 3-yd. trailers. The cost of hauling and spreading gravel by four White trucks for the period July 1, 1915, to May 1, 1916, was as follows:

	Yards hauled.	Total cost.	Average haul.	Class of road hauled over.	Cost per yard.	Cost per yard. mile.
[illegible]	[illegible]	[illegible]	8.9	Very hilly	$0.9834	$0.1104
[illegible]	[illegible]	316.54	11.4	Very hilly	1.2104	.1061
Sept.	[illegible]	400.68	9.36	Very hilly	1.0544	.1126
Oct.	233.	325.48	8.3	Very hilly	1.3969	.1680
Nov.	959.	319.28	8.	Hilly	.3329	.0416
Dec.	537.	294.58	2.7	Hilly	[illegible]	.2031
Jan.	414.	185.14	3.0	Hilly	.447	.149
Feb.	1013.5	308.38	1.1	Hilly	[illegible]	.2763
March	1294.	526.66	3.1	Gravel	[illegible]	.131
[illegible]	[illegible]	420.14	3.65	Gravel	[illegible]	.138
	6259.0	$3,422.91				
July	1711.5	319.58	1.26	Soft gravel	.1867	.1481
[illegible]	[illegible]	283.35	2.1	Loose gravel	.2753	.1310
Sept.	1121.5	461.22	3.43	Loose gravel	.4112	.1198
Oct.	607.	346.22	4.	Loose gravel	.5703	.1425
Nov.	[illegible]	336.57	[illegible]	Loose gravel	.5046	.1009
Dec.	471.	329.54	5.6	Loose gravel	.6996	.1249
Jan.	385.5	280.97	6.	Loose gravel	.7288	.1214
Feb.	459.	310.98	3.6	Loose gravel	.677	.188
March	1456.	452.49	2.3	Gravel	.3107	.135
April	1470.	381.40	2.95	Gravel	.26	[illegible]
	9377.5	$3,502.32				
July	[illegible]	[illegible]	3.	Very good	.4580	.1526
Aug.	711.	236.73	2.9	Loose gravel	.3329	.1147
Sept.	793.	429.59	3.38	Loose gravel	.5417	.1602
Oct.	431.5	363.07	4.2	Loose gravel	.8414	.2003
Nov.	691.	390.34	4.6	Loose gravel	.5676	.1233
Dec.	480.	433.75	5.5	Loose gravel	.9036	.1642
Jan.	782.	297.99	3.45	Gravel	.381	.110
Feb.	921.	401.87	2.8	Loose gravel	.436	[illegible]
March	1750.	609.53	2.9	Gravel	.348	.120
April	1778.	449.79	2.5	Gravel	.253	.101
	9225.1	[illegible]				
Jan.	490.	247.46	1.8	Hilly	.505	.280
Feb.	962.	242.21	1.6	Loose gravel	.256	[illegible]
March	1565.	522.24	1.9	Gravel	.333	.175
[illegible]	[illegible]	[illegible]	[illegible]	Gravel	[illegible]	[illegible]
	4061.	$1,457.00				

Total [illegible] ..... [illegible]
Total yard miles ..... [illegible]
Total cost $12,401.62
[illegible] ..... [illegible]
[illegible] ..... [illegible]
[illegible] ..... [illegible]
[illegible] ..... [illegible]
[illegible] ..... [illegible]
Maximum haul ..... [illegible] miles
Minimum haul ..... [illegible] miles
Average haul ..... 3.2 miles
[illegible] month ..... [illegible]
[illegible] month ..... [illegible]
[illegible] month ..... [illegible]

The total cost of the Municipal Building of New York City to date is $12,400,314, of which $11,745,128 is for construction proper and $685,186 for architects' services.

SHORT COURSE IN HIGHWAY ENGINEERING AT UNIVERSITY OF MICHIGAN.

The College of Engineering of the University of Michigan will give its third annual short course in Highway Engineering at the University, in Ann Arbor, Mich., during the week of Feb. 19 to 23, 1917.

In the conduct of this course the same plan will be followed as in former years. The instruction will be given from the viewpoint of road conditions in Michigan and especially for the benefit of highway commissioners, highway engineers, contractors and others interested in the construction and maintenance of roads. The course is a continuation of the work done in the past two years, but arrangements will be made for those coming the first time. The subjects treated will be those of finance, construction and maintenance of roads.

The instruction will be under the supervision of the Engineering Faculty of the University of Michigan and the Michigan State Highway Department. This will be supplemented by several lectures given by prominent highway engineers and state highway commissioners of various states throughout the country.

No charge will be made for those taking the course, and it is open to anyone interested in highway problems, without examination or other prerequisites.

NEWS LETTERS.

St. Louis Items.

Harrington Bros. were awarded the contract for grading 50,000 yards of property work in the west part of the city.

The French and Italian governments closed a contract here last week for 6,500 additional horses. The English government has ceased buying, as it did last year at the beginning of the winter The market at the National Stockyards for mules and horses to be shipped to the southern states is better now than it has been for several years, owing to the high price s and big cotton crop.

The L. J. Smith Construction Co., Commerce building, Kansas City, Mo., was awarded the contract for building an 85-mile extension for the Santa Fe Railroad between Shattuck, Okla., and Hansford, Texas. There is approximately 2,500,000 yards of grading in this job, of which 600,000 yards is rock. They also are to lay the track, build the depots, bridges, section houses, roundhouses, fences, and, in fact, complete the line ready for operation. Will sublet any part of this to responsible contractors.

J. C. Paquette, 455 Morgan St., Elgin, Ill., writes us that he has a 16-team outfit idle at that point.

Stanley E. Bates, editor in charge of the Contractor, spent a couple of days here with us.

The Callahan Construction Co. has finished its work on the east side of the river here and is offering the dragline it had on this job for sale. Its headquarters is Omaha, Neb.

R. A. Brown & Co., 3115 Bond Ave., East St. Louis, Ill., have 15,000 yards of grading at South Wood River, Ill., to sublet.

Rust & Swift, who were awarded a government revetment and shore protection job at the last letting in Rock Island, Ill., are going to begin work above Grafton, Ill., as soon as the weather and river will permit them in the spring.

Labor is more plentiful right now than it has been for several years. Contractors in want of men can have their orders filled promptly if they will send them to Koenig's Labor Agency, St. Louis or Kansas City, Mo.

The Mineral Refining & Chemical Corporation, which is completing its $1,000,000 plant beside the Mississippi River at the River Des Peres, near Ivory Station, has obtained an option on 21 additional acres. Jose Marimon, president of the company, proposes investing $1,500,000 additional in the plant. All the land has been acquired from the Missouri Pacific-Iron Mountain Railway, on whose tracks it is located. The 21 acres just optioned are situated on the River Des Peres. The site of the plant, which is nearing completion, immediately adjoins this land on the north and embraces 33 acres. The corporation therefore has 54 acres for its industrial expansion. Jose Marimon, who is president of the Banca Espanola of Havana, Cuba, expects to be in St. Louis in a few weeks, when he will arrange to put the factory in commission. The corporation will manufacture paint pigments. Marimon, according to statements made by his associates, who are Cuban and Spanish capitalists, has just bought all the telephone and telegraph lines of Cuba. He paid $12,000,000 for these properties. As the St. Louis plant is situated on the Mississippi River, the company will have two economic advantages. Water may be taken free from the river, and steamers and barges may be operated direct between St. Louis and Havana, or between St. Louis and cities on the waterways. Using the river for transportation is one of the projects which the company has in view.

John Scott & Sons, Pierce building, St. Louis, Mo., were awarded the contract for a 65-mile extension for the Santa Fe Railroad southwest of Lubbock, Texas. In addition to the grading this firm is also going to do the track laying, build depots, section houses and everything on the line.

J. P. Hickey of Hickey Bros. came in from Seneca, S. C. to spend the holidays with his family here. Jack reports that they will complete this job in the early part of 1917. A. B. KOENIG.

PERSONALS.

T. B. Shertzer, Assoc. M. Am. Soc. C. E., of the Texas Co., New York City, has been appointed city manager of Portsmouth, Va.

L. D. Hollingsworth has been appointed division engineer of the Kentucky Public Roads Department, with headquarters at Paducah, Ky.

J. E. Johnson has been appointed county superintendent of highways, with offices at Princeton, Ill. He succeeds F. R. Bryant, whose resignation becomes effective in February.

The Central Construction & Supply Co., of Harrisburg, Pa., has been reorganized and will engage in general contracting under the name of the General Construction Corp. Geo. E. Tripp, formerly vice-president of the United Gas & Electric Corporation, New York City, is president of the new company, and Joseph H. O'Brien, formerly managing engineer of Westinghouse, Church, Kerr & Co., New York City, is vice-president.

Moses Stoppard for the past twelve years superintendent of the water department of Binghamton, N. Y., has resigned that position owing to ill health. He is succeeded by Frederick E. Beck, civil engineer of the Water Commissioners.

J. E. Bebb, heretofore office engineer of the Duluth, South Shore & Atlantic Ry., with headquarters at Duluth, Minn., has been appointed assistant bridge engineer of the Michigan Central Ry., with headquarters at Detroit, Mich., effective January, 1917.

B. J. Simmons has been appointed division engineer of the Atchison, Topeka & Santa Fe, with headquarters at Needles, Cal., to succeed W. L. Bradley, transferred. He will have jurisdiction over maintenance of way, bridge building and water service matters.

Max. R. Hall, who has been for years a member of the firm of Hall Brothers, consulting engineers, Atlanta, Ga., has been appointed assistant chief of construction of Atlanta, Ga., effective Jan. 1. B. M. Hall, M. Am. Soc. C. E., M. Am. Inst. M. E., and B. M. Hall, Jr., will now constitute the membership of this firm of civil, mining and hydraulic engineers, with offices in the Peters building at Atlanta, which has been its location since 1910.

The Oklahoma Society of Engineers, at its meeting at Tulsa, Okla., Dec. 28, elected the following officers for the year 1917: President, Alfred Boyd, dean of engineering, A. and M. College, Stillwater; first vice-president, Max L. Cunningham, state engineer, Oklahoma City; second vice-president, Frank B. King, corps of engineers, Lawton; third vice-president, T. P. Clonts, county engineer, Muskogee; secretary-treasurer, H. V. Hinckley, consulting engineer, Oklahoma City.

The Watson Co., engineers, a corporation organized for that purpose, on Jan. 1 took over the business of Wilbur J. Watson & Co. The offices will be located at the same place as heretofore, namely, 1150 Leader-News building, Cleveland, and the personnel of the company will be practically the same as before, with the addition of H. H. Hick, formerly with Geo. S. Rider & Co., as building engineer, and H. R. Hadlow, formerly in business at 918 Citizens' building, Cleveland, as mechanical engineer. The personnel of the new company will be as follows: President and chief engineer, Wilbur J. Watson; vice-president and principal assistant engineer, W. P. Brown; secretary and treasurer, Samuel F. Agnew; designing engineer and in charge of drawing room, F. L. Gorman; construction engineer, R. S. Ferguson; building engineer, N. H. Hick; mechanical engineer, H. R. Hadlow; assistant engineers, A. M. Felgate, W. J. Wefel and E. W. Bowen; inspecting engineer, H. H. Smith.

James G. Travilla of St. Louis, Mo., has become connected with the Dunn Wire-Cut Lug Brick Co. of Conneaut, O., in the capacity of consulting engineer. Mr. Travilla is a graduate in the civil engineering course of the University of Pennsylvania and has also taken a post-graduate course. During his professional career he has been in the engineering department of the Missouri Pacific R. R. at St. Louis; assistant engineer in the water works department, St. Louis; for several years in charge of the estimating and drafting division of the street department, St. Louis; superintendent of the street department; street commissioner under Mayor Rolla Wells (Democrat), and under Mayor Frederick W. Kreigman (Republican). Mr. Travilla resigned in 1912 as street commissioner of St. Louis and until 1916 had supervision and direction of the expenditure of $1,000,000 for good roads in Tarrant County, Texas; also directed road work from proceeds of bond issues in other Texas counties. In March, 1916, Mr. Travilla was appointed consulting and associate engineer by the County Court of St. Louis County, Missouri, for a $3,000,000 road system. This work was stopped by a ruling of the Supreme Court declaring certain road statutes invalid, and Dec. 1, 1916, Mr. Travilla joined the engineering department of the Dunn Company.

The Engineers' Subdivision of the Chicago Association of Commerce has announced the winners in the prize contest for engineering papers, written by undergraduates and recent graduates of technical colleges and universities. First prize of $50 was awarded to Harvey T. Hill, Field Museum, Jackson Park, Chicago, graduate of Pennsylvania State College, 1915. The subject of Mr. Hill's paper was "Engineering and Civic Progress." Second prize of $30 was awarded to Leo Shippy, 2903 West street, Ames, Iowa, mechanical engineer junior at Iowa State College, who wrote on the subject of "The Engineer of the Future." Third prize of $20 was awarded to H. M. Kistler, 6737 Penn avenue, Pittsburgh, Pa., graduate of Pennsylvania State College, 1916, his subject being "The Engineer of the Future." Eleven universities were represented in the contest by those who submitted papers, which was announced in September, the prizes offered for the best articles on any one of three subjects, as follows: (1) "Engineering and Civic Progress," (2) "The Engineer of the Future," (3) "The Business Relation of the Engineer to the Commercial World." Honorable mention was also given by the judges to the papers prepared by R. D. Stitt, 72 West Adams street, Chicago, graduate of the University of Illinois, in 1915, on the subject of "The Business Relation of the Engineer to the Commercial World," and Gordon D. Cooke, 160 Dexter boulevard, Detroit, Mich., graduate of the College of Engineering, University of Michigan, in 1916, on the subject of "Chartering Rocks and Reefs on the Great Lakes." The technical schools represented are as follows: Pennsylvania State College, Iowa State College, Universities of Cincinnati, Cornell, Illinois, Michigan, Minnesota, Pennsylvania, Purdue, Washington and Worcester Polytechnic. The judges of the contest were: Prof. F. H. Newell, University of Illinois; Dean John F. Hayford, Northwestern University, and John W. Alvord, consulting engineer, and member of the Engineers' Subdivision of the Association of Commerce.

OBITUARIES.

Edmund B. Weston, consulting engineer, Providence R. I., died Dec. 9 at a hospital in Boston, Mass., aged 66 years.

James Skene, a well known contractor, died Dec. 23 at Seneca, S. C., of pneumonia, aged 71 years. At the time of his death he was doing some work on the Southern Ry. He was born in Aberdeen, Scotland, and came to this country when a young man. As superintendent and contractor he was identified with much important construction work. His principal work was on difficult bridge foundations. He built and had charge of several such contracts for structures over the Missouri and Rio Grande rivers and had an important part in the construction of the foundations of the well known high bridge over Kentucky river for the Queen & Crescent Ry. He constructed several river locks and dams for the United States government. Mr. Skene was buried at Huntington, W. Va. He leaves a wife, three sons and two daughters.

INDUSTRIAL NOTES.

Andrew Fletcher, member of the executive committee of the American Locomotive Company, has been elected president of the company, to take effect Jan. 1, 1917. Mr. Fletcher succeeds W. H. Marshall, who recently resigned.

The Pulsometer Steam Pump Co. has opened a branch office in Detroit, Mich., under the direction of its western distributors, May & Talley Co. The office will be in charge of John Cavan, and is located on the fourth floor of the Penobscot building.

Water Works and Hydraulics Issue
of
Engineering and Contracting

Halbert P. Gillette, *President and Editor*

First Wednesday Each Month............Roads and Streets......$1 Yearly
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"THE CHINESE ECONOMIC PARADOX—LABOR TOO CHEAP TO REPAY SAVING IT WITH MACHINERY."

In two recent contributions by engineers, one on reinforced concrete and the other on earthwork in China, the statement is made that no mechanical plant was used because it could not compete in cost with Chinese labor.

Coolies receive not more than 15 ct. in gold per day. At this price, railway embankments are built by contract for less than 4 ct. per cu. yd., the earth being carried in baskets an average distance of 1,000 ft., or nearly a quarter of a mile. Accordingly it would seem that because the Chinaman is inefficient without machinery, he must perforce receive small wages, and, in consequence of small wages, it will not pay to provide him with machinery. In other words, labor is so cheap that labor saving can not be effected!

This is an old argument, and some writers have gone even further, asserting that it would be the greatest of disasters were labor saving machinery introduced extensively into China, because so many men would thereby be deprived of a livelihood. This is the ancient labor union sophism by which it is sought to defend opposition to labor saving devices. Let us consider briefly the problem that confronts the engineer or contractor who goes to China. Must he leave behind all thought of using machinery because the fixed charges—interest and depreciation—plus repairs will, when added to labor and fuel, exceed the cost of labor unaided by machinery? We doubt it.

The types of machines that have the best chance of competing with human labor are those whose first cost and upkeep expenses are relatively small. This at once points toward all hand operated devices, such as push carts, small derricks, concrete chutes, rod benders, and a thousand and one labor saving devices operated by muscular power. These, without question, can be used profitably even where labor costs only a cent or so an hour; for the repair item itself consists mostly of labor in making repairs.

The next class of devices that can undoubtedly be used in China, if there is work enough in sight to warrant their purchase, is the class that requires steam or petroleum power on a small scale, such, for example, as riveting hammers, air-hammer drills, small hoists, etc. The investment in these is small, yet the increased output that men effect by their use is enormous. It should be remembered that it takes 10 men to do a horse-power of work, and that, consequently, where the work is continuous a 10 h.p. engine or motor delivers as much work as 100 men. A gasoline engine requires about a pint of "gas" per horsepower hour, so that at even 40 ct. a gallon the gasoline costs only 5 ct. an hour per horsepower. Hence the fuel cost is equivalent to half a cent per man-power per day, assuming continuous work.

Even very small sizes of gasoline engine cost only $40 to $50 per horsepower in America, and weigh about 50 lb. per horsepower. Allowing 3 per cent of the first cost for monthly interest, depreciation and repairs, we have $1.50 per month or 6 ct. per day per horsepower for "plant charges," or only about one-tenth of the cost of the gasoline. Evidently, then, we can enormously increase the investment per horsepower before the "plant charges" on such an engine become worthy of serious consideration in comparison with the work done. If an engine costs $100 per horsepower in China, and if gasoline were 40 ct. a gallon, the cost of fuel and "plant charges" would total only 62 ct. per 10-hour day per horsepower. Large as this is, let us compare it with the cost per horsepower delivered by coolie labor at 15 ct. per 10 hr. day. Since it takes 10 coolies to deliver a horsepower, the cost of coolie work is $1.50 per horsepower day, or 2.5 times that of gasoline engine power under the conditions above named.

This analysis serves to bring out two important facts: First, that the Chinese attendance and "plant charges" on an engine that is at work 150 days a year are nominal and may be ignored when making comparison with muscular work. Second, that the fuel item, for small engines, is the determining factor where foot-pounds of energy are being purchased, and that gasoline at $1 a gallon yields about the same cost per foot-pound, or horsepower, as coolie labor at 1.5 ct. an hour.

It should not be overlooked that once a Chinaman has been shown how to do a thing, he seldom forgets his lesson. Consequently the installing, moving and operating labor, as well as repair work, will be performed by Chinamen at their exceedingly low rates of wage. An engineer must, therefore, not estimate the labor operating costs of power plants on an American basis, even as to the item of repairs.

Certainly for the smaller sizes of easily portable construction machinery there is even now no justification for the claim that Chinese labor is too cheap to warrant the use of machinery, provided the machinery can be kept fairly busy for a few years.

In a land of cheap grain, it is self-evident that all horse-operated machinery can be profitably used, provided the horses can be kept fairly busy. Hence with hand tools, horse-operated machinery and small gasoline-driven plants that can economically assist labor in China even now, we may expect a steady increase in their use until within, say, 10 years there will be no type of construction equipment that will not be used there.

With extensive application of machinery there will come higher wages for the Chinese, for a general increase in output inevitably brings an increase in the average wage. The higher wages paid in Japan are evidence of what is in store for the Chinese once they are taught to adopt American and European tools and methods; yet Japan itself is far from a high state of efficiency because it lacks sufficient plant.

WHY ENGINEERS SHOULD ORDINARILY INSIST THAT INSPECTORS BE ENGINEERS.

Whether construction work is done by contract or by day labor it should be subject to continuous inspection by competent, honest men. Both competency and integrity are more likely to be secured where trained engineers are employed than where "skilled workmen" or political appointees are the inspectors. This fact has been repeatedly established, but the repetition seems not to have stirred many engineers to action.

Mr. H. S. Morse, engineer of the Detroit Bureau of Governmental Research, has recently reported on sewer construction in Detroit, and has scathingly arraigned the inspection of sewer work. The inspectors are usually "political ward workers" who are paid $4 a day for pretending to inspect construction. Lacking the necessary engineering training, they are incompetent to perform what is a very important engineering function—to see that the designs and specifications are lived up to.

In deepening the Erie Canal 20 years ago, a scandal developed because the appropriation proved inadequate. This led to an investigation that disclosed not a single case of dishonesty among the engineers or their subordinates, but it did disclose a number of cases of "irregularity" on the part of inspectors. The public, however, never differentiated between the engineering department and the department of public works, although the latter appointed the inspectors who were culpable.

In the interest of his own professional reputation, to say nothing of that of engineers in general, every engineer in charge of public work should insist that the inspectors of his work be competent engineers free from political debts to the appointing agency. An inspectorship forms excellent training for young engineers, and should be the stepping stone to a higher engineering position.

Although Mr. Morse in his report, does not go so far as to urge that the sewer inspectors of Detroit be engineers, he does condemn the political system that has secured the present type of inspector. A somewhat long and wide observation of the inspection of public works throughout America has convinced the editor that the incompetence of the average public works inspector arises primarily from his ignorance of engineering.

WHEN PETROLEUM IS GONE, THEN WHAT?

The underground supply of petroleum in America will be exhausted in 30 years, according to the Geological Survey. This estimate is based on the assumption of present annual production and on calculated quantities of oil in known oil fields. Both assumptions are wrong, for the present rate of oil consumption will rise greatly every year and new oil bearing sands will be discovered. However, it seems assured that petroleum will grow rapidly scarcer and that its price will rise unless some substitute is discovered or developed.

The Geological Survey has been at work for some time on the problem of extracting petroleum from hydrocarbon shales. A report on the subject is now in press, and advance announcements indicate that the Geological Survey believes that it will be commercially practicable to distil crude oil from certain shales. It is stated that from shale beds in Colorado alone there can be extracted 20,000,000,000 bbl. of crude oil, which at present prices would be worth $30,000,000,000.

Important as this source of fuel oil seems to be, we doubt whether it offers an adequate solution of the problem. In all likelihood the cost of mining and distilling shale will be such as to make the cost of the crude oil very much higher than the prices now paid for it. If so, the economic advantages of shale oil as a fuel may be offset by its excessive cost.

It seems altogether more attractive to study the possibilities of powdered coal as a substitute for fuel oil and possibly for gasoline itself. In a recent issue we gave data relative to the economy of the use of powdered coal on certain locomotives running between Chicago and Milwaukee. It should be added fully three-fourths of the Portland cement in America is burned with powdered coal, and that therefore the use of this form of fuel is by no means experimental.

Mr. Henry B. Pruden, of the Powdered Coal Engineering and Equipment Co., Chicago, claims to have perfected a "powdered coal carburetor" that completely solves the problem of burning coal without smoke and with a very high efficiency. The next great step forward would seem to be the development of a "carburetor" that will permit the use of powdered coal in place of gas or gasoline in an internal combustion engine. This would do away with the necessity of generating steam to develop power from coal.

The occasional explosions of coal dust in mines and of flour dust in flour mills long ago made it evident that finely comminuted carbon acts like gas. The problem therefore resolves itself into reducing coal to fine powder and exploding it in an engine cylinder with air.

Several lines of experiment suggest themselves. For example, if a large part of the nitrogen were removed from the air, leaving mainly oxygen to enter the "carburetor" with the coal dust, the explosion probably would be more powerful even with coal less finely powdered.

The coal now used for power purposes in America annually costs a billion dollars. By the use of powdered coal for steam boilers, it is probable that 20 per cent of this expenditure can be saved. But if we can go a step farther and explode the powdered coal in engine cylinders, it should be possible to save 40 per cent of the present fuel consumption for power.

The internal combustion engine, using powdered coal, appears to offer a better solution of the crude oil problem than is to be had by distilling hydrocarbon shales; and, in addition, it would solve many more fuel problems of even greater economic importance.

In a few years the Chicago business man may say:

"John, is the reservoir full of powdered diamonds?"

"Yes, sir."

"Is the oxygen tank fully charged?"

"Yes sir."

"Well, take the elevated street to Milwaukee and get me there in an hour and a half."

THE ECONOMY OF KEEPING WATER MAINS CLEAN.

A thing unseen is apt to be a thing forgotten. If the inside of every iron pipe were suddenly made visible by some x-ray, what a house-cleaning waterworks managers would order at once.

We all know that iron rusts, and that tubercules gather in pipes, and that each hump and hollow causes an eddy, and that each eddy causes friction that consumes power. We know all this, but because we do not see it we forget its real import, and, forgetting, we allow coal to be burned uselessly. We say uselessly, for periodic cleaning of water pipes would reduce the cost of pumping to a marked degree.

The cost of pumping is, however, not the only cost that can be reduced by keeping pipes clean. In most cases it is the least part of the saving that can be effected through pipe cleanliness. Water pipes designed and located by engineers are given diameters that will insure a flow of a definite quantity of water per minute under a definite pressure. The engineer of course provides for the "peak loads" due to conflagrations, but, in doing so, he assumes that the pipes will be fairly clean, so that the friction will consume only a given part of the pressure. Let the pipes become foul with rust, and all the calculations are upset, for the pressure at the hydrant becomes less than was provided for during a fire. Hence the fire department finds itself unable to battle effectively with the flames, and fire losses are increased.

To avoid possibility of such a serious loss, engineers frequently give mains a factor of safety against loss of head from tuberculation of the pipes; that is, they make the pipes considerably larger than they would need to be were they kept clean. But when this is done, money is unnecessarily invested in pipe metal, for periodic cleaning of the mains would enable the engineer safely to specify smaller mains.

Looked at from any angle, whether as a matter of pumping economy, pipe economy, or fire loss, it is evident that water pipes should be kept clean. Indeed we might go farther and urge that they be kept polished, for a very slight difference in smoothness of a 6-in. to

12-in. pipe alters the quantity of water delivered to a degree that is really remarkable.

Study the "coefficients of roughness" periodically, and you are likely soon to form the habit of periodically cleaning your water mains.

POLISHING CENTRIFUGAL PUMP IMPELLERS AS A MEANS OF INCREASING EFFICIENCY.

Although the skin friction of water on any surface over which it flows is known to increase with the roughness of the surface, probably few engineers appreciate the great effect of polishing the impellers of a centrifugal pump. Skin friction also increases as the square of the velocity, so that even slight roughness of an impeller moving at high velocity reduces the efficiency to a marked degree.

Bearing upon this matter some recent experiments with screw propellers are illuminating. Mr. William McEntee, in a paper read at the last annual meeting of the Society of Naval Architects and Marine Engineers, stated that propellers with unpolished cast surfaces showed a maximum efficiency of 63 per cent, where the same propellers when polished gave an efficiency of 72 per cent. By artificially roughening the surface to imitate pitting through corrosion, the efficiency was reduced to 36 per cent.

The obvious inference is that money invested in a bronze or brass impeller that has been well polished will produce a handsome dividend on the investment wherever a centrifugal pump is worked with any considerable continuity.

EDITORIAL COMMENT.

Mr. F. W. Park has called our attention to the fact that the R. M. Kellogg Co. farm at Three Rivers, Mich., mentioned in our last Waterworks and Hydraulic Monthly issue, is no longer the largest farm using the Skinner overhead pipe system of irrigation. The Seagraves Farm Co., Bridgeton, N. J., now has 130 acres under overhead piping. This puts the Kellogg farm of 120 acres in second place. Mr. Park also informs us that J. R. Davis, Barton, Fla., has 100 acres under irrigation by the overhead system. Mr. Davis has a brother who operates a successful large overhead system at Aurora, Ill. It will pay engineers who are interested in irrigation to look into the results that are being secured by overhead or sprinkling systems of irrigation.

In excavating the site of a 1,200,000-gal. reservoir at Sioux Falls, S. D., Mr. Dabney H. Maury, consulting engineer, of Chicago, unwatered the ground effectively as follows: At each corner of the reservoir (116x116 ft.) a 10-in. well was driven 20 ft. below the bottom of the proposed excavation. A steam siphon was used to blow out the wells and remove sand; then they were connected with the waterworks pump, and the water table was thus lowered below the bottom of the proposed reservoir. This is unwatering ground by the "bleeding method" on a larger scale than we have ever heard of, for the usual plan is to use small pipes driven close together.

A good deal of the sewer construction in Detroit is done by day labor. Mr. H. S. Morse, formerly Engineer of Sewers of Cincinnati, has recently made a report that indicates a condition bordering on economic chaos as a result of there being no detailed record kept of the cost of the Detroit sewer work performed by city forces. He recommends that the superintendent of the sewer department be required to bid in competition with contractors, basing his bid on carefully kept cost data of his own past work. Good! Now go this one better: Let an outside, competent engineering inspector see that the sewer superintendent lives up to the specifications, and an outside, competent cost analysis engineer see that all the elements of cost are included in the superintendent's records of cost.

CONSOLIDATION OF THE TWO WATERWORKS ASSOCIATIONS.

To the Editor.—I am very much in favor of consolidating the two Waterworks Associations. There is no reason whatsoever for maintaining the two societies, apart because of some sectional pride, and some previous misunderstandings, while there are many reasons for consolidation.

By having a larger membership, the society could do more good for its members and the public, by having more select articles on various phases of the work. At present many of the articles are so elementary in their nature, that it is a waste of time to read them.

It would attract many eminent engineers to join a society which was truly national, who do not care to join either society at present. This would improve the society both technically and financially. To the waterworks men who now belong to both societies it would be of great advantage to have only one set of publications and that of a more select nature, than the two at present; also only one due to pay instead of two, and one annual meeting instead of two.

Personally I can see no reason why there should be any jealousies, even amongst the older men, and I would welcome a consolidation of the two societies. I would also suggest that if the two societies are consolidated that they should make their headquarters in the engineering building in New York City instead of being homeless wanderers.

A. Gideon,
Manila, P. O. Supt. Water Supply & Sewers.

To the Editor: The consolidation of professional and semi-professional organizations is, to my mind, devoutly to be wished; the holding of fewer conventions exceedingly desirable, and the lessening in numbers of technical journals a hoped-for boon to the practitioner.

Let organizations have great breadth in scope and territory, with local sections and specialized divisions.

In these sections have the greatest latitude of paper and discussion, but permit the full publication only of such papers as make for real enlightenment.

To satisfy the desire for publicity, perhaps publish a very brief and well-edited resume of local papers and discussions, as a matter of record and to be an inducement to the presentation of written and spoken thought.

There has been too much of paper, time and money wasted in fostering separate organizations and journals having somewhat allied interests, due very largely to desire for personal rather than general advancement.

When conventions are held let them be centrally located, largely attended and held primarily for technical gain and acquaintance, with enough of the social side for relief, rather than as too often practically the prime object.

In specific answer to your question: Yes—consolidate the American Water Works and New England Water Works Associations.

Louis L. Tribus,
New York City. Consulting Engineer.

PATENT CLAUSE IN SPECIFICATIONS.

To the Editor: For many years a clause has been inserted in standard specifications for municipal contracts, or purchases, with the idea of protecting the cities against claims for infringements of patents on appliances, materials, or methods used. The plan has been to require the general contractor to assume and take charge of the defense to any action, or suits, that may be brought directly against the said contractor, or city and to indemnify and save harmless said city, its officers and agents from all loss, cost, or damage arising from any such action or suits.

This has been of considerable protection to municipalities constructing sewer, or water systems and such a clause is practically printed in every engineer's specifications.

The original intent, however, was to protect the cities from any claims that might be made by parties not furnishing equipment claiming infringement by those who did furnish apparatus, or against the contractor for processes, etc., familiarity with which the city was not expected in any way to have had, and it is doubtful whether such a standard clause in the specifications was ever intended to, or would, cover a direct patent obligation, for which the city, or its agents, had made agreements with the patent holder, unless the amount of the contract covering the fees agreed upon, was given in advance to the contractor, so that his bid should cover and include it.

The Imhoff tank has been presented to the American public on a basis of a very moderate scale of royalty fees, based on the population tributary to the tanks as designed and constructed, and many engineers have considered that the Imhoff royalty fee should be clearly understood and if paid by the contractor, he should be advised in advance of his bid to the city and required by the specifications to pay to the American agents, the amount of the fee, securing their receipt and surrendering same to the city before a settlement of his contract.

To avoid any error, or misunderstanding, engineers have frequently printed in the specifications the amount of the Imhoff fee, to whom paid and specified the surrendering to the city, of a receipt showing payment by the contractor, before final settlement.

There is always a likelihood of a patent claim not being taken seriously, especially in connection with sewage disposal. There have been so many fake claims made, so much talk of litigation, so many letters written to the public, etc., that this viewpoint is not so surprising.

Engineers who specify that the contractors shall pay all claims for royalties, patents, etc., under their general and stereotyped form, may find that their clients will be obliged to pay the Imhoff fee twice. The first time, as included in the general contractor's bid, and the second, time, to the direct owner of the patent, after a suit.

It would appear to be necessary for an engineer drawing his specifications, or for a city building Imhoff tanks, to either specify the amount of the fee in the specifications, to whom it shall be paid and demand a receipt from the contractor before settlement for the work is made; or to eliminate the Imhoff royalties from the general contract and so state in the specifications, at the same time specifying that the city will pay the Imhoff fee direct. Obviously if the city pays the fee for a recognized patent claim, as covered by the contractor's bid, it (the city) should have and hold the license to operate the patented process, or apparatus—the city's interest in the matter not being protected in any way, otherwise.

S. Fischer Miller, President.

Pacific Flush-Tank Co., American and Canadian commercial representatives of Dr. Karl Imhoff, Essen, Germany.

WHAT IS A COLLEGE FOR?

To the Editor: My attention has been called to an exceedingly valuable article in your issue of Nov. 1, 1916, written by Prof. H. P. Boardman, and entitled "What Is a College For?" With your kind permission, I should like to emphasize and endorse in your paper some of the leading points of the letter and make a few remarks of my own.

The question of "What Is Life For?", suggested by Prof. Boardman, is directly to the point; and upon its answer will depend the methods of teaching most advantageous to adopt. If, as Prof. Boardman indicates, the object is to obtain the greatest possible personal gain, irrespective of the rights or welfare of others, then an engineering course might best be confined entirely to those technical and business studies which fit a man for the acquisition of wealth. But if the object be to become a useful and respected member of society, a good citizen, and a true gentleman in the strictest sense of the word, as well as a good engineer, the course should include many studies that are not directly related to technics or business, but which treat of the humanities, general culture and political economy.

In the community the engineer is the man who is typical of progress; and his work is for the benefit and betterment of mankind; hence his education should be along lines tending directly towards that desideratum. Ethics should certainly be an important feature of all technical curricula.

I do not agree with President Wilson that the engineering schools are for training "workmen" and the colleges for training "master-workmen"; for I think that ordinary workmen should be trained in trade schools, and master-workmen in engineering schools—and especially in the engineering department of our great universities.

The man who "looks down on ordinary people as merely 'workmen' or people in the 'ranks'" is certainly a snob and unworthy of belonging to the great profession of engineering.

The fundamental mistake which is being made today in technical education is the adjusting of the curriculum to the intelligence and working capacity of the average student, and, at the same time, permitting mediocre men to enter the course, thus holding back the good, energetic men and preventing them from attaining their maximum of accomplishment.

In my opinion, the best possible solution of the broad question of technical education is the establishment of really good and effective trade schools for the mediocre men; cutting out much of the purely technical work in the existing engineering courses, and substituting therefor cultural, business and economic studies of a general nature (at the same time increasing the thoroughness of the theoretical instruction so as to accommodate the great majority of the men of superior intelligence and energy); and the establishment of post-graduate schools of the highest order for the truly brilliant or the unusually diligent men. If a boy or a young man is found to be too superior for the trade school he should be transferred to a higher institution of learning. By adopting this suggested method of technical instruction, the country would soon be provided with a small army of well-trained workmen, a sufficiency of high-grade, cultured engineers of broad viewpoint, and a few professional men of eminence, thoroughly trained in special lines of engineering activity. This method is much better than that of providing an average course for the great mass of engineers, which would give the lower grade men too exalted notions of their standing and a distaste for manual labor, which would turn out mere technists lacking in culture, and which would fail utterly to provide facilities for specially educating the men who are destined eventually to climb to or very near the top of the professional tree.

Prof. Boardman is right when he says that "the importance of the more subordinate positions is not sufficiently emphasized." Anyone who does his work thoroughly and intelligently, and who is a good citizen and a moral man, should receive the unqualified respect of the community, even if he does not succeed in setting the world on fire by his brilliancy; and anything that can be done to improve the general status of such a man is an important step in the right direction.

Prof. Boardman says "Much criticism is aimed at engineering education and its failures properly to educate engineers, but little in the way of concrete suggestions of a practicable workable nature is offered." Is not this statement rather sweeping? Some of the writers on technical education have made most pertinent suggestions as to how to effect the necessary improvements. One of the best of these is to weed out from technical pedagogy all the indolent, the unpractical, the inefficient, the unenthusiastic, and the narrow, hide-bound teachers, and replace them by better men. To do this, however, would call for a general increase in instructors' salaries; and such an increase of material proportions most assuredly is long overdue.

Although for the last three decades I have been advocating the establishment of five-year and even six-year courses for engineers, I have lately come to the conclusion that such courses would not be suited to the requirements or, more strictly speaking, to the desires of most young Americans; for they are generally too eager to make a start in the real business of life. It is only the far-sighted and truly ambitious ones that would be willing to devote more than four years to their technical education; and for these the post-graduate courses are what is needed. Such courses should specialize in all the important branches of the engineering profession; and the instruction therein should be given by experts.

I desire strongly to emphasize what Prof. Boardman says concerning the necessity of instructing engineering students in public speaking—this is a matter of prime importance. Again, I heartily advocate having engineers "keep in close touch with the public questions of the day and not be so wrapped up in technical things that they are not even intelligent voters." Until this glaring defect of engineers in general is corrected, our profession will not be recognized at its true worth by the community; and its members will continue to be ranked in a class inferior to that occupied by the members of the so-called learned professions.

In my opinion, specializing in the ordinary engineering course is a mistake, as it tends to make the men narrow-gauge; but it is eminently proper for a post-graduate school of engineers.

Finally, in regard to all that Prof. Boardman says in opposition to the "selfish, 'look-out-for-number-one' point of view" and in favor of the altruistic, I beg most heartily to concur.

J. A. L. Waddell,
Consulting Engineer.

Kansas City, Mo.

PIPE-BENDING MACHINE.

A labor-saving device is used by the Philadelphia Suburban Gas & Electric Co., Chester, Pa., for the cold bending of 8-in. pipe. The machine is described by Charles Wilde, Engineer of Mains, in a paper presented to the October meeting of the American Gas Institute. The arrangement consists of a 10-in. I-beam, 10 ft. long, braced with 1¼-in. tie rod, two ¾-in. chains 8 ft. long and an ordinary 20-ton screw jack and block. To operate, all that is necessary is to link the chains around the pipe and I-beam by means of a slip link, place the jack and pipe block in position between the pipe and the beam, and then by the force of the jack make the bend. If the bend required is only a slight one, it may be made without any shift of the machine. If it is a bend of any considerable extent, the machine should be shifted one way or the other, bending the pipe a few degrees until the required bend is made.

Machine for Bending Pipe.

With this machine four men can make a bend in an 8-in. pipe, depending, of course, upon the radius and degree of the bend required, in from ½ to 2½ hours, or a labor cost of from 50 ct. to $2.50 per bend. To make the same bend—when possible to be made—in the old way would require about 25 men, who would never lose less than half an hour from their regular work, which would mean a minimum cost of $3.13, and would often require twice this time.

CLEVELAND ACCOUNTS FOR 94 PER CENT OF ITS PUMPED WATER.

Cleveland, O., according to a statement of Mr. C. F. Schulz, Engineer of the Water Department, in the December Journal of the American Water Works Association, accounts for about 94 per cent of the water pumped. This is an unusually large percentage. In fact, a plant that accounts for 80 per cent is considered to be very efficient. Mr. Schulz gives the following table, showing the percentage of water used at Cleveland for various purposes and the percentages unaccounted for in 1913, 1914 and 1915:

	1913.	1914	1915.
Nominal pumpage during the year	27,099,632,372	29,803,485,871	28,557,394,916
Slippage through pumps estimated at 3 per cent	812,988,986	894,104,576	856,721,847
Total consumption to be accounted for, gallons	26,286,643,386	28,909,381,295	27,700,673,069
Total consumption to be accounted for, per cent	100	100	100
Metered and sold, per cent	82.98	78.57	82.03
Metered but free	5.72	6.32	6.74
Total registered by meters	88.70	84.89	88.77
Slip of meters, estimated at 3 per cent	2.66	2.55	2.66
Total water passing through meters	91.36	87.44	91.43
Estimated use of water by those paying on assessment basis*	0.047	0.01	0.062
Hydrant rentals*	0.12	0.11	0.144
Building purposes*	0.17	0.21	0.369
Sprinkling streets*	0.107	0.03	0.024
Estimated consumption for miscellaneous purposes not covered by hydrant rentals, building permits, etc.*	0.36	0.33	0.180
Unmetered free water for testing meters, building sewers, paving streets, puddling trenches, flushing water mains, flushing sewers, watering troughs, parks and fountains, fire extinguishment, etc.	2.45	1.94	2.07
	94.61	90.07	94.17
Leakage from pipe system†	1.10	1.40	1.20
Total accounted for	95.71	91.47	95.37
Unaccounted for	4.29	8.53	4.63

*Estimated consumption for the purposes mentioned was determined by calculating the quantity of water that the money received on the assessment basis would pay for at the uniform metered water rate of 5⅓ cents per thousand gallons. The actual quantity used for these purposes and the quantity wasted no doubt greatly exceeded this estimate.

†Based on reports of leaks discovered by the waste detections department. No data as to duration of leaks. Data not reliable.

The discharge mains of all the pumps are metered with Venturi meters, which show on an average not over 1 per cent of pump slippage. However, in accounting for the water pumped, 3 per cent is deducted from the pump plungers' displacement to determine the water delivered to consumers, the result is called 100 per cent. Besides Cleveland, the Water Department is supplying about 13 villages with water. The department has about 950 miles of water mains with over 95,000 service connections, exclusive of village mains and services. About 99 per cent of all services are metered. The metered water accounts for 88 per cent of the water considered to have been delivered by the pumps, after deducting 3 per cent for slip of pumps and calling that quantity—i. e., the quantity delivered by the pumps—100 per cent. A record is kept of all the water used for putting out fires, which is not much over 40,000,000 gal. for the entire year, or half a day's consumption. An accurate record also is kept of the water used for settling trenches, flushing sewers and for flushing mains and for various other purposes. For instance, there is one gang that flushes dead end water mains continually throughout the year. In addition there are a few connections that are not metered. Unmetered water is also furnished to public utility corporations for construction purposes. It is assumed that the quantity of unmetered water furnished for these various purposes amounts to less than 3 per cent of the total pumped. All these together amount to about 94 per cent of the total pumpage.

SOME USES TO WHICH A RIVER CURRENT MAY BE PUT.

By Halbert P. Gillette.

Undershot waterwheels were common a century ago, and still are used occasionally. There are other uses to which the energy of a river may be used, some of which are but little known to engineers. Most of us have seen ferries operated by the power of a current, but how many have ever seen a "rudder boom," or a "river kite?" About 14 years ago I published a description of a "rudder boom" and a mathematical analysis of the forces that act upon it. It seems wise to reprint that matter together with some suggestions as to other uses to which the power of river and tidal currents may be put.

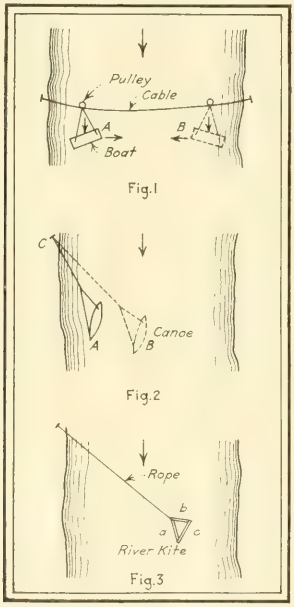


Fig.1

Fig.2

Fig.3

Figs. 1-3—Some Uses of River Current.

Ferry Boat.—Figure 1 is a sketch showing how a ferry boat is driven across a river by the energy of the current. A wire cable spans the stream and along the cable travels a pulley or "trolley" from which run two ropes, one short rope to the bow, the other, and longer rope, to the stern of the boat. On the return trip, the bow becomes the stern, as shown at B, and the boat travels in the opposite direction.

Cordelling a Canoe.—Figure 2 shows another application of the "river kite" principle. A canoe, A, is held by a rope from the bank. By paying out the rope, the canoe will travel from A to B, and so on across the river. It will stand stationary at any desired place in the river. The writer has used this method for taking soundings across a very swift stream. Also it can be used in handling a pile-driver scow, or in placing a timber grillage upon a submerged pile foundation. Indians "cordell" a canoe up a river, one or more men, "c," walking up the bank pulling the rope, while one man in the canoe at A pushes with a pole.

River Kite.—Figure 3 shows a "river kite," in which "c" is a 2x12-in. plank, 3 ft. long. To its top edge are spiked two laths, "a" and "b," "a" longer than "b." The plank "c" floats on edge in the river, like a rudder. By paying out the rope that holds it, the "kite" can be "flown" from one bank to the other. It can be used to carry a rope across a stream. The writer first devised this "kite" for holding a net out in a stream, to guide salmon into a revolving "fish wheel." The net took the place of the rope shown in Fig. 3. A large "river kite" may be used to hold a log boom out in a river, but a better device for this purpose is the "rudder or shear boom" shown in Fig. 4.

Rudder Boom.—A "rudder boom" was built about 16 years ago at the Snoqualmie Falls power plant, near Seattle. The "rudder boom" is a device very commonly used by Western shingle mill operators for the purpose of diverting floating cedar "bolts" into a pocket-boom, where they are caught, and carried up by an endless chain conveyor into the mill, where they are sawed into shingles.

The application of the same device to diverting drift wood from the intake of the pipe, at Snoqualmie Falls, is an example of the inventive resources of American engineers.

There are undoubtedly many engineers in the East who have never seen, and possibly never heard, of a rudder boom, but the instances where it can be used to advantage are not few in number. At Niagara Falls, for example, the ice that is drawn into the penstocks in the spring of the year seriously interfere with the operation of the turbines, yet trouble from this source could be entirely avoided by the use of the rudder boom. So far as the writer is aware no published description of such a boom exists, neither is there any published data for computing the dimensions of the rudders, etc.

In 1893, the writer was inspecting some bridge work close to a shingle mill, where one of these booms was being built, and watched with interest the progress of the building. Before it was launched out into the river, the writer, having applied his theoretical mechanics to the problem, ventured the prediction that more rudders would be required to carry the boom out to the desired angle with the current. The builder, a practical man, had little respect for anything theoretical, and hearing the prediction he lost no time in offering to wager a box of cigars that the boom would work as it was. It is doubtful whether the writer, who had no great confidence in his own theory, would have accepted the wager, but for the greater fear of ridicule that would follow being "bluffed." The boom was finished and finally launched, and swung gracefully out into the current until it reached its limiting angle. The builder continued to smoke a pipe while he sawed the wood for more rudders!

When first seen, the rudder boom looks very much like an example of "lifting yourself over a fence by your boot straps;" for the same river current which tends to force a long stick pivotally connected at one end to the bank, into a position parallel with the bank itself, is made to carry that same stick out until it forms an acute angle with the current and stays there.

Figure 4 shows the boom after it has assumed a position of equilibrium in the river. The behavior of the rudder boom, however, differs in no wise from that of a kite; for the river current corresponds to the air current; the boom corresponds to the kite string, and the rudders correspond to the kite itself; therefore, a rudder-boom might not inaptly be called a river-kite.

As commonly built the boom consists of two lines of 12x16-in. timbers (t), bolted together and arranged so as to break joint. Hinged to the down-stream side of the boom are the rudders or "fins" (r), made of 3x16-in. plank standing edgewise in the water, spaced about 12 ft. apart; each being about 12 ft. long.

The free ends of the rudders are fastened to a small wire cable (c), passing around a sheave (s) to the drum of a winch (w), which is mounted on the boom itself.

The boom is anchored to the river bank with another wire cable fastened to a deadman or tree (d), and its end is held away from the bank by a short strut (p). When first built the boom lies anchored parallel with the river bank, but when finished the cable (c) is wound up on the drum of the windlass by men using cranks, until the rudders assume an angle with the current which impinging upon them drives the boom, rudders and all, out into the stream. It then assumes the position as shown in Fig. 4, where the moment of the force of the current upon the boom just equals the sum of the moments of the force of the current acting upon the rudder, the center of moments being C. Were it not for certain indeterminate factors, the exact position that the boom would take under given conditions might be calculated; as it is, a very close approximation can be made by the formula that will be presently deduced.

Assuming that the force of the current acting upon the boom is practically the same in pounds per square foot as is the force acting upon the rudders, it will appear from the formula that the velocity of the current is immaterial, and a given rudder boom will assume the same position in a river, whether its velocity is 2 miles an hour or ten.

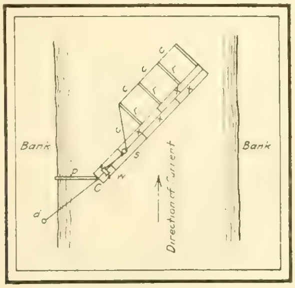


Fig. 4—Rudder Boom.

Practically, there is some difference in the pressure upon booms and rudders, for the current loses some velocity in passing under the boom before it reaches the rudders, due to eddies generated. Furthermore, the direction of the current as it rises from under the boom and strikes the rudders, is not exactly horizontal.

There is, however, another factor that in a measure counterbalances this lost velocity, for the velocity of a river current is greater in the center of the stream than near the bank, and, if properly constructed, most of the rudders will be located near the center of the stream, so as to receive the greatest possible impact; while few if any rudders will be located near the bank end of the boom.

In the demonstration that follows we shall assume the force, f, of the current to be uniform upon both boom and rudders, and we shall neglect the small factor of tangential friction of the water upon the boom and rudders. External forces like wind and accumulated drift will also be ignored, although they have at times a marked effect, especially where the river velocity is low.

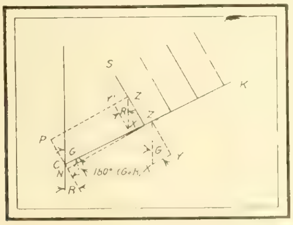


Fig. 5.

In Fig. 5 let C K be the boom pivoted at C, and O S be one of the rudders hinged at O, and let X Z be the direction of the river current. Draw X Y parallel with C K, and Z Y perpendicular to C K, then if X Z = f be the unit pressure of the river current, Y Z will be the normal unit pressure upon the boom. Likewise draw X′Z′, parallel with the current Z′Y′, perpendicular to the rudder, O S, then Y′Z′ will be the unit current force normal to the rudder.

Let G = the angle Z X Y that the boom makes with the current.

R = the angle Z′X′Y′ that the rudder makes with the current.

l = length C K of boom in feet.

r = length O S of rudder in feet.

x = Distance of hinged end of rudder from center of moments, C.

f = pressure of current, lbs. sq. ft.

d = submerged depth of boom in ft.

d′ = submerged depth of rudder in ft.

M = moment of boom about C.

M′ = moment of rudder about C.

Draw C P parallel with O S, Z′P parallel with C K, O Z′ being = Z′S, and draw O N parallel with P Z′. Then,

$$Y Z = X Z \sin G. \qquad (1)$$

$$= f \sin G. \qquad (2)$$

$$M = \frac{l}{2} (ld) f \sin G. \qquad (3)$$

$$Y'Z' = X'Z' \sin R. \qquad (4)$$

$$= f \sin R. \qquad (5)$$

$$M' = C P r d' f \sin R. \qquad (6)$$

$$C P = \frac{r}{2} - x \cos (180 - G - R). \qquad (7)$$

$$M' = r d' f \sin R \left[\frac{r}{2} - x \cos (180 - G - R). \right] \qquad (8)$$

If there is equilibrium $M = \Sigma M'$ and

$$\frac{l^2}{2} d f \sin G = \Sigma r d' f \sin R \left[\frac{r}{2} - x \cos (180 - G - R). \right] \qquad (9)$$

Since f appears as a factor in both members of Equation 9 it may be dropped, showing, as above stated, that the force of the current is immaterial.

From Equation 9, given the length and submerged depth of boom, and the angle at which it is desired to hold it, one may calculate the number, size and location of rudders, and by a few approximations, the angle of maximum efficiency R may be calculated, R being ordinarily about 45°, or a maximum value of R may be determined by the well-known differential coefficient method of calculus.

A Suggested River Current Motor.—It is evident that if a rudder boom were so designed that its rudders would be automatically released when the boom had swung out to an angle of 45° with the current, the current would drive the boom back till it became parallel with the current. Then if the rudders were set again at an angle with the current, the boom would move back into the river. By repetition of these back and forth swings of the boom, a considerable amount of power could be developed. By trussing the boom, and by the use of very large rudders near its free end, it is evident that in a swift current several horsepower could be developed with a relatively short boom.

This device would have the merit of being supported by the water, and would therefore accommodate itself to the rise and fall of the stream. It would be superior to a windmill because of the comparative uniformity of the velocity of the current. It would be superior to an undershot waterwheel, in that it would receive the impact of a much larger volume of water, and particularly of water moving at a higher velocity than that near the river bank.

A Suggested Pontoon Swing Bridge.—In war time frequently and in peace occasionally, a pontoon bridge must be built. The "rudder boom" suggests a solution of this problem. The floats supporting the roadway could be pivoted thereto, and, after the bridge had been built along the river bank, it could be swung across the river from bank to bank by turning the floats as the rudders are turned on the boom. The swinging of the bridge would require only a few minutes, and it could be even more quickly withdrawn.

The American Dredging Co., of Philadelphia, Pa., has been awarded a contract by the U. S. Government for dredging near Philadelphia, requiring over 7,000,000 cu. yds. of excavation.

CINCINNATI METHOD OF AGITATION OF SURFACE OF FILTER BEDS LENGTHENS PERIOD OF SERVICE.

Experiments conducted last summer at the filtration plant of Cincinnati, O., have resulted in the development of a modified method of operation whereby the periods of service of the filters can be greatly increased. The results of these experiments were set forth in a paper prepared by J. W. Ellms, Superintendent of Filtration, and Stephen J. Houser, Bacteriologist and Chemist of the Cincinnati Waterworks, and read at the New York City convention of the American Chemical Society. This paper brings out so many points of interest to water works operators that it is given below practically in full.

The troubles produced by micro-organisms in the operation of the rapid sand filter plant at Cincinnati have been entirely those caused by shortened periods of service. The organism that has usually been found to be the most numerous at these times when the filters clogged rapidly, was Synedra delicatissima.

The character of the organic matter in the Ohio River water during the summer and fall months is such that it forms a rather heavy colloidal coating on the sand grains that is particularly effective as a filtering medium. In consequence it becomes possible to operate filters to a comparatively high loss of head and still produce an effluent of high quality. From 10 to 11 ft. loss of head can usually be obtained and still maintain a rate of filtration equivalent to about 125,000,000 gal. per acre per day. The period of service at this rate may range from 3 hours to 70 hours. In a general way decreased periods of service of the filters coincide with increased numbers of micro-organisms; but this parallelism does not always hold, and seems to indicate that associated organic matter of a colloidal character must contribute materially to the clogging effect.

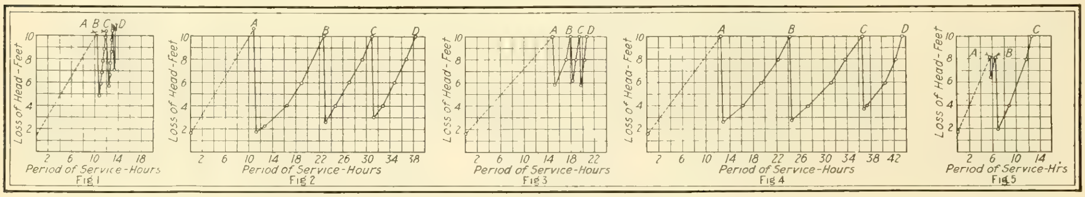


Fig 1 Fig 2 Fig 3 Fig 4 Fig 5

Figs. 1-5—Diagrams Plotted from Results of Experiments 1 to 5 Inclusive.

When filters are operated to a high loss of head, air is usually liberated from the water and becomes entrained in the sand bed. The escape of some of this air takes place, of course, when the effluent valve of the filter is closed, and filtration ceases. More air escapes upon the application of wash water. It was noted in the operation of the Cincinnati filters that merely by closing the effluent valve, with the consequent escape of some entrained air, and then reopening this valve, the loss of head decreased, and a further period of service could be obtained. Accordingly, systematic experiments were commenced during a period of shortened filter runs, to determine to what extent disturbance of the sand surface by various methods had upon the period of service of the filter and on the quality of the filtered water.

In Table I experiments 1 and 3 show the effect of closing the effluent valve at a loss of head of 10 ft. or over, and the consequent escape of some of the entrained air. On an average it will be seen that at each closing of the effluent valve an increase of about 10 per cent of the normal period of service was produced. In other words, without any washing or agitation of the filter bed, other than that produced by the escape of entrained air, the filter run was lengthened about 30 per cent. It will be also seen that the bacterial efficiency of the filter was not affected. The loss of head plotted against the period of service is shown in Figs. 1 (experiment 1) and 3 (experiment 3). This brings out very clearly the recovery of the loss of head by the slight disturbance of the bed caused by closing the valve.

The data in Table II, experiments 2 and 4 show the result of opening the wash water valve slightly, and of forcing filtered water up through the sand bed after the effluent valve had been closed. Two effects are here combined, namely the disturbance of the sand bed produced by the escape of all of the entrained air, and by the movement of a small quantity of filtered water up through the sand bed.

It will be seen that this method entails no loss of water, and that approximately the period of service was increased over 250 per cent, as compared with 30 per cent in experiments 1 and 3. It will be again noted that the bacterial count is not affected by this method of agitating the bed.

The loss of head in these experiments will be found plotted against the periods of service, Figs. 2 (experiment 2) and 4 (experiment 4) respectively.

In order to eliminate the effect on the sand bed of the escape of entrained air, an experiment was made in which the effluent valve was closed when the loss of head was sufficiently low to prevent the liberation of air from the water. The results given in Table III (experiment 5) illustrate the effect of closing the effluent valve without liberation of air, followed by the effect of water agitation. The water was applied in the same way as in experiments 2 and 4. It will be observed, that merely closing the effluent valve has some slight effect in reducing the loss of head. The marked effect, however, is that produced by the opening of the wash-water valve, and shows that there can be effected an increase of practically 100 per cent in the length of the period of service for the same loss of head. The plotted figures are shown in Fig. 5 (experiment 5).

In order to show the practical benefit to be derived from this modified method of operation of filters, that are filtering water infested with micro-organisms, the combined data of the operation results of the Cincinnati filters between Aug. 27th, 1916, and Sept. 16th, 1916, both inclusive, are given in Table IV. From Aug. 27th to Sept. 3rd a progressive reduction in the period of service of the filters may be seen. On the latter date, the modified method of operating was commenced. This method consisted of closing the effluent valve when the loss of head reached about 10 ft., and opening the wash water valve so that filtered water passed upward through the sand bed for about one minute, and at a rate of about 5,000 gal. per minute. No water was wasted to the sewer. Ten minutes after the effluent valve was closed, it was reopened, the opening of the wash water valve having taken place during this period. The loss of head usually fell back to less than 2 ft. and the period of service was increased thereby nearly 100 per cent. This operation was repeated twice thereafter or three times in all, the same as in "experiments 2 and 4."

Up to Sept. 6 the bacteria in the filtered water remained low and the number were fairly uniform. In order to learn the effect on the filters of applying copper sulphate to the settled and applied water, 0.48 p.p.m. was introduced into the settled water and 1.2 p.p.m. into the applied water on Sept. 6th. The amounts used were known to be insufficient to effect complete removal of the diatoms, and since the Ohio River was the source of the supply of organisms, only temporary reduction in the number in the settled water could be hoped for. Some reduction was produced.

The anticipated result following the application of copper sulphate to the settled and applied water, namely, a tremendous increase in the bacterial content of the water, took place on Sept. 7th. To counteract this increased bacterial load on the filters, chlorine was applied to the filtered water, beginning Sept. 6th and was discontinued on Sept. 15th. The bacterial content of the chlorinated filtered water is uniformly low.

TABLE I.—EFFECT OF CLOSING EFFLUENT VALVE OF FILTER AT HIGH LOSS OF HEAD AND WITH ESCAPE OF ENTRAINED AIR.

Experiment 1. (Aug. 8, 1916.)

Period of service. Hr.	Min.	Loss of head feet.	Bacteria per cc.
10	20	10.6 (A)	12
Effluent valve closed for 10 min. and then opened.			
0	15	4.8	25
0	30	5.8	16
0	40	6.8	11
0	50	7.8	14
1	0	8.8	10
1	15	9.8	4
1	40	10.4 (B)	6
Effluent valve closed for 10 min. and then opened.			
0	15	5.6	15
0	25	6.6	12
0	30	7.6	8
0	35	8.6	8
0	40	9.6	7
1	0	10.4 (C)	4
Effluent valve closed for 10 min. and then opened.			
0	10	7.0	6
0	30	10.6 (D)	7

Total period of service, 13 hr. 30 min.

Average number of bacteria per cc., 10.

Experiment 3. (Aug. 28, 1916.)

Period of service. Hr.	Min.	Loss of head feet.	Bacteria per cc.
14	50	10.0 (A)	12
Effluent valve closed for 10 min. and then opened.			
0	5	....	23
0	15	5.8	14
2	20	8.0	12
2	50	10.0 (B)	10
Effluent valve closed for 10 min and then opened.			
0	5	....	25
0	15	6.2	12
0	50	8.0	10
1	40	10.0 (C)	8
Effluent valve closed for 10 min. and then opened.			
0	5	....	20
0	15	5.8	14
0	25	6.0	12
0	45	8.0	9
1	20	10.0 (D)	9

Total period of service, 20 hr. 30 min.

Average number of bacteria per cc., 14.

Referring again to Table IV, the practical value of the modified method of operating filters, is clearly proven by the great saving effected in the wash water used. During the period between Sept. 3rd and Sept. 16th, the volume of wash water estimated to have been saved amounted to 68,773,000 gal. The actual percentage of wash water used was 2.78 per cent. The percentage of wash water that would have been required if this modified method of operation had not been used is 11.16 per cent.

TABLE III.—EFFECT OF CLOSING EFFLUENT VALVE AT SUCH A LOSS OF HEAD THAT NO AIR WAS ENTRAINED, AND OF CLOSING THE EFFLUENT VALVE AGAIN AT THE SAME LOSS OF HEAD, FOLLOWED BY THE APPLICATION OF WASH WATER FOR ONE MINUTE AT A RATE OF 5,000 GAL. PER MINUTE.

Experiment 5. (Sept. 1 1916.)

Period of service. Hr.	Min.	Loss of head feet.	Bacteria per cc.
5	25	8.4 (A)	7
Effluent valve closed for 10 min and then reopened.			
0	5	....	9
0	15	6.4	9
0	40	8.4 (B)	8
Effluent valve closed, wash water applied, and effluent valve reopened.			
0	5	....	15
0	15	2.0	10
2	20	4.0	7
5	5	8.0	5
6	5	10.0 (C)	5

Total period of service, 12 hr. 10 min.

Average number of bacteria per cc., 8.

Note.—No attempt made to repeat wash water application and thus lengthen period of service. Experiment made to demonstrate that the breaking of the surface coating on the filter bed, whether by the escape of entrained air as shown in Experiments 1 and 3 (Table I), or by the application of wash water without the escape of air, is the effect which must be produced in order to lengthen the period of service.

The conclusions to be drawn from these experiments are summarized as follows:

1. The growth of micro-organisms in surface waters that are filtered may produce, if in sufficient quantity, serious clogging of the sand beds. In the operation of rapid sand filters, the increased percentage of wash water required, and the resulting decreased capacity of the plant as a whole presents an important problem.

TABLE II.—EFFECT OF CLOSING EFFLUENT VALVE OF FILTER AT HIGH LOSS OF HEAD AND OPENING WASH WATER VALVE FOR ONE MINUTE, AND WITH ESCAPE OF ENTRAINED AIR. RATE OF APPLICATION OF WASH WATER, 5,000 GAL. PER MINUTE.

Experiment 2. (Aug. 10, 1916.)

Period of service. Hr.	Min.	Loss of head feet.	Bacteria per cc.
10	45	10.6 (A)	18
Effluent valve closed, wash water applied, and effluent valve reopened.			
0	5	....	24
0	20	1.7	17
2	0	2.2	9
5	25	4.0	10
7	50	6.0	11
11	55	10.0 (B)	12
Effluent valve closed, wash water applied, and effluent valve reopened.			
0	5	....	40
0	15	2.6	24
2	0	4.0	18
4	10	6.0	15
6	20	8.0	10
8	0	10.2 (C)	8
Effluent valve closed, wash water applied, and effluent valve reopened.			
0	5	....	12
0	15	3.0	12
2	[illegible]	4.0	15
4	0	6.0	13
5	55	8.0	10
7	40	10.2 (D)	7

Total period of service, 38 hr. 20 min.

Average number of bacteria per cc., 15.

Experiment 4. (Aug. 29, 1916.)

Period of service. Hr.	Min.	Loss of head feet.	Bacteria per cc.
12	15	10.0 (A)	11
Effluent valve closed, wash water applied, and effluent valve reopened.			
0	5	....	30
0	20	2.4	25
1	35	4.0	17
3	30	6.0	15
9	10	8.0	12
11	15	10.0 (B)	11
Effluent valve closed, wash water applied, and effluent valve reopened.			
0	5	....	45
0	15	2.8	29
4	0	4.0	17
6	55	6.0	14
9	40	8.0	16
12	30	10.0 (C)	12
Effluent valve closed, wash water applied, and effluent valve reopened.			
0	5	....	17
0	15	3.8	20
0	45	4.0	27
3	0	6.0	23
5	10	8.0	21
7	15	10.0 (D)	20

Total period of service, 43 hr. 15 min.

Average number of bacteria per cc., 20.

2. Periods of service of filters may be increased by agitating the surface of the filter bed by closing the effluent valve and opening the wash water valve slightly for a short time, without permitting any wastage of water to the sewer. Probably agitation with compressed air will effect a like result, since the escape of entrained air in these experiments indicated that the air alone produced a sufficient disturbance of the surface coating of the sand bed to reduce the loss of head.

3. The agitation of the surface of the sand bed can probably be repeated until the recovery of the loss of head is not sufficient to warrant further operation of the filter. Care must be taken, however, that the sand bed does not become too heavily or too deeply loaded with organic matter, and that finally a thorough and efficient washing of the bed is absolutely essential.

TABLE IV. ACTUAL RESULTS OF USUAL AND MODIFIED METHODS OF OPERATION OF THE CINCINNATI FILTERS WHEN APPLIED WATER WAS INFESTED WITH MICRO-ORGANISMS

Date.	Period of service. Hours Normal	 Including extended periods.	Bacteria per c.c. Filtered water Effluent from filters.	 Outlet F. W. reservoir.	Total water filtered, gals.	Wash water used, gals.	Wash water saved, gals.
Aug. 27	23.21		7	16	[illegible]	744,000	
28	22.66		11	27	[illegible]	[illegible]	
29	[illegible]		11	37	[illegible]	1,176,000	
30	12.16		12	38	[illegible]	1,658,000	
31	9.61		12	26	[illegible]	2,364,000	
Sept. 1	7.33		12	[illegible]	[illegible]	2,928,000	
2	5.81		9	[illegible]	[illegible]	3,768,000	
3	*4.42	17.[illegible]	[illegible]	32	[illegible]	[illegible]	2,994,000
4	*[illegible]	13.25	10	33	[illegible]	1,482,000	4,464,000
5	*[illegible]	11.19	[illegible]	[illegible]	[illegible]	1,924,000	5,762,000
†6	*2.25	8.98	[illegible]	*23	[illegible]	2,808,000	8,406,000
7	[illegible]	10.36	[illegible]	*12	52,292,000	1,812,000	5,454,000
8	*2.50	10.00	470	*20	[illegible]	2,505,000	7,515,000
9	*2.93	11.72	460	*13	59,945,000	[illegible]	5,520,000
10	*[illegible]	[illegible]	430	*10	47,138,000	1,242,000	3,720,000
11	*[illegible]	15.76	260	*[illegible]	[illegible]	1,362,000	4,074,000
12	*[illegible]	14.38	130	*12	[illegible]	1,688,000	5,056,000
13	*3.74	14.97	85	*23	59,972,000	1,440,000	4,332,000
14	*4.12	16.49	85	*[illegible]	60,055,000	1,308,000	3,940,000
15	*4.04	16.17	[illegible]	*32	[illegible]	1,326,000	3,996,000
16	*4.23	16.93	55	60	[illegible]	1,104,000	3,540,000

*Estimated hours of service for the first period.
†0.48 p.p.m. of copper sulphate applied to the settled and 1.2 p.p.m. to the applied water
*0.15 p.p.m. of chlorine applied to the filtered water from Sept. 6 to Sept. 15.
Note.—Average volume of wash-water used per wash 60,000 gals.

4. The bacterial efficiency of filters operated according to the method suggested, is high, and no deterioration in the quality need be anticipated if the sand is properly and thoroughly washed.

5. The marked saving in the volume of wash water, the maintenance of the rated capacity of the plant through lengthened periods of service, and the decreased labor of operation, are all factors of importance that should commend this modified method of procedure to operators of filter plants, when troubles with micro-organisms are experienced.

PROPORTIONAL FEEDING DEVICE FOR WATER PURIFICATION PLANTS.

Within the last two or three years there has arisen a demand for proportional feeding devices in connection with water purification plants. This demand has in a way assumed the nature of a mild contagion and in many instances such feeds are suggested as necessary, or at least most desirable in plants whch have no need for such control.

In many plants which operate with controllers, and in which the volume of water handled is constant per unit in service or where calibrated controllers are in use, the usual manual-controlled orifice will give entire satisfaction. The use of the manually controlled orifice does away with the need of a more or less delicate machine with moving parts and, when there is not absolute necessity for a proportional feeding device, would seem the most satisfactory.

To meet the demand for the proportional feeding device the New York Continental Jewell Filtration Co. has developed and has in successful operation a device which is shown in Figs 1 and 2. A brief outline of its operation follows:

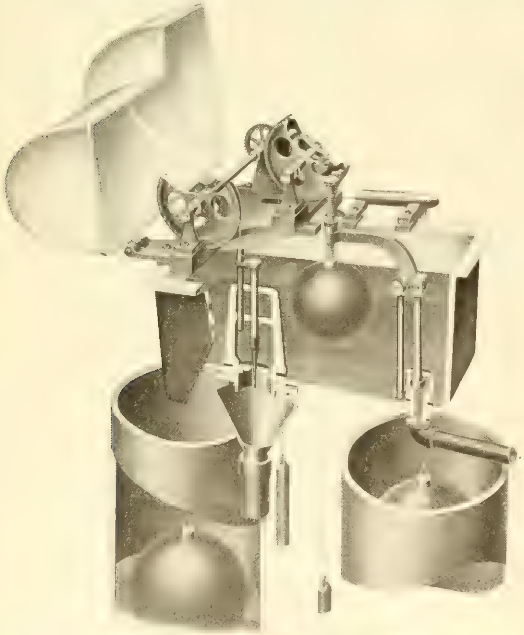


Fig. 1—View Showing Controlling Apparatus.

The apparatus utilizes the differential head obtained by a differential pressure tube through which the flow to the plant is passing to operate a mechanism by which the movement of a needle in an annular orifice will give a flow of chemical in proportion to the flow of water in the line. This device is for use with low heads of water, and the differential head usually employed at maximum capacity of the device is about 24 in. There are connections to the line and throat of a differential pressure tube which transmit these pressures through small pipes to float tubes, as shown in Fig. 2. With 24 in. difference in level in the float tubes, the rise of the needle shown in Fig. 1 is 2 in. from the closed position. The reduction in movement of the needle as compared with the difference in level in the float tubes is obtained by a system of gearing.

To set the machine at zero—that is, at position corresponding to no flow in the line—an equalizing valve between the two connections to the differential pressure tube is opened and the line pressure transmitted to both float tubes. With the float tube thus in equilibrium, the mechanism is so adjusted that the needle in the orifice is just closed. When the equalizing valve is then closed and the two connections to the differential pressure tube open, the needle will then rise an amount corresponding to the differential head due to the flow through the line at the time.

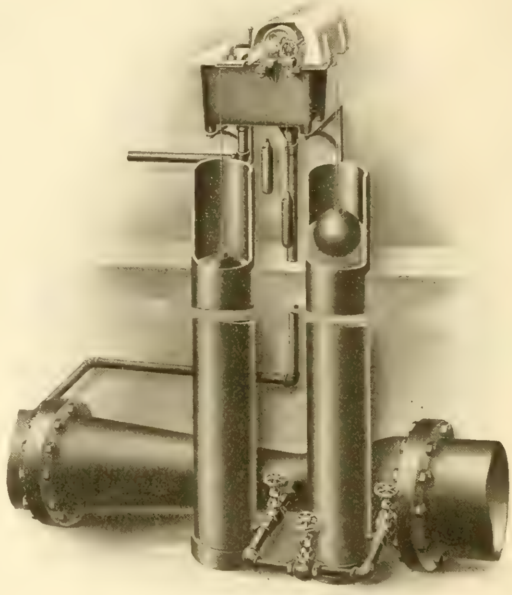


Fig. 2—View Showing Float Tubes.

The needle is so formed that the position which it assumes in the orifice under any flow insures the discharge of chemical for a definite dose, regardless of the rate of flow of water to the plant. To increase or decrease the dose different needles may be substituted or the strength of solution may be changed, basing the change on the strength of solution for which the unit dose was computed with the needle furnished.

The main shaft which operates the sheave over which the orifice needle is suspended can be extended so that two or three needles can be operated with one set of float tubes and gear mechanism. Thus provision can be made for proportional feeding of several chemicals, as, for instance, soda ash or lime and hypochlorite, in addition to the sulphate of alumina, by the addition of orifice boxes and needles designed for the desired strength of solution or dose required.

At Flemington, N. J., a duplex device is in use for feeding sulphate of alumina and hypochlorite of lime. The needle for the hypochlorite solution feed is designed to give one part per million dose of available chlorine with $\frac{1}{3}$ per cent solution hypochlorite and the needle for the sulphate of alumina solution a dose of one grain with a 2 per cent solution. Of course the strength of solution used and the size of needles would be adapted to the needs of any plant.

The capacity of the filter plant at Flemington, N. J., is 325,000 gal. per 24 hours at the normal rate—that is, 2 gal. per square foot of filtering surface per minute.

The orifices for chemical solution feed are maintained under a constant head of 3 in. of solution at the Flemington, N. J., plant. The head is kept constant by means of a float-controlled chemical inlet valve, but the head of solution over the orifices could be adjusted—that is to say, increased or decreased—according to the requirements of design or capacity of the plant in which it is to be used.

The gearing of the machine is such that it transmits to the needle only a movement corresponding to the differential head due to a flow in the line, and any variation of head or pressure in the line has no effect on the position assumed by the needle.

ACCOUNTING FOR THE WATER SUPPLIED.

The town of Belmont, Mass., was able to account for 82½ per cent of the water supplied in 1915, according to a statement by Charles W. Sherman, Consulting Engineer, in the December Journal of the American Waterworks Association.

This town is a suburb of Boston, and is a residential community of 8,000 people, with no manufacturing, but where there is a considerable use of water by market gardeners. The water supply is obtained from the Metropolitan Water Works, and is metered at the town line, where it is furnished, into the distribution pipes. The distribution system consists of 31½ miles of main pipes 2 in. to 12 in. in diameter, and 14¾ miles of service pipes, with 1,430 services. It has been fully metered since 1898. The daily consumption for 1915 averaged 52 gal. per capita.

Not only are all the services, including municipal buildings, supplied with meters, but there are meters on watering troughs, etc., and the water department furnishes a man and a meter to measure the water used for sewer flushing. In fact, practically all the water used is metered, except that drawn from fire hydrants for extinguishing fires.

The proportion of the water supplied, which has been thus accounted for, has been as follows:

	Per cent.
1908	67.2
1909	65.6
1910	58.5
1911	61.0
1912	62.3
1913	64.2
1914	71.9
1915	82.5

No definite data are available to indicate where the unaccounted water goes. In 1910, following the decrease in the proportion which could be accounted for, it was thought that there must be a considerable number of leaks in the main pipes, and great pains were taken to find such leaks. These efforts did not meet with much success. Some leaks were found, but none of much consequence, and as shown by the percentages, the gain in the next three years amounted to only about 5 per cent. It was then concluded that greater care in looking after house meters might show a further gain. Previously they had received good ordinary care; they were supposed to be read monthly, and it was believed that a meter could not be stopped or in bad condition for any considerable period without discovery. However, beginning with 1914 a systematic following up of all meters was undertaken, and no meter was allowed to stay in service more than a certain limited time, without removal, testing and cleaning. This policy resulted in a gain of 7 per cent in the water accounted for in the first year, and a further gain of 11 per cent in the following year. How much further gain can be accomplished in this way is not known, but the officials are inclined to believe that not over 10 to 15 per cent of the water supplied is lost through main pipe leaks, and it may be possible to account for between 85 and 88 per cent of all the water supplied.

In this connection it may be interesting to note that in 1915, in the high service district of Belmont, a section including about two miles of 6-in. and 8-in. pipe, on a portion of which the pressure exceeds 160 lb. per square inch, and 47 services the percentage of the water supplied which was metered to consumers, was 94.

SUSPENSION METHOD AND AUTOMATIC OSCILLATING DEVICE FOR OVERHEAD IRRIGATION SYSTEMS.

In many overhead irrigation systems the nozzle lines are supported on wooden or pipe posts. These posts are preferably about 7 ft. high, are arranged in straight lines and spaced 15 ft. to 20 ft. apart. A slightly more expensive method of installation, but one that reduces to a minimum the interference to cultivation due to the location of the posts, is known as the suspension method. This consists in suspending the pipes from small wire cables, thus greatly reducing the number of supporting columns.

Under the suspension plan posts or iron pipes are placed rigidly in the ground every 100 ft. to 150 ft. along the length of the line. These columns extend about 15 ft. above the ground and carry a small cable from which the nozzle lines are suspended at a length of 6½ ft. to 7 ft. above the ground. Figure 1 illustrates the method. Referring to this sketch the dimensions used in best practice are as follows: For distances between posts not exceeding 125 ft.—E-B, 100 ft. to 125 ft; A-B, 13½ ft.; B-C, 3 ft; B-D, 6 ft.; posts, 2½ in. or 3 in. pipe or 6 in. wood; suspension cables, ¼ in. galvanized stranded cable. For distances between posts of 150 ft. maximum —E-B, 125 ft. to 150 ft.; A-B, 14½ ft.; B-C, 3½ ft.; B-D, 6 ft.; cable, ¼ in. or ⅜ in. stranded galvanized wire; posts, 3 in. pipe or 6 in. wood.

The nozzle line is generally suspended from the cable by No. 14 galvanized wire, to which is attached a hanger. This hanger in the Skinner system is a hook saddle having two rollers on which the nozzle line rests. The supporting wires are spaced every 10 ft. where ¾ in. pipe is suspended; every 12 ft. for 1 in. or 1¼ in. pipe, and every 15 ft. for 1½ in pipe.

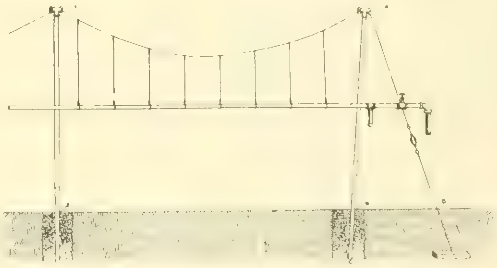


Fig. 1. Suspension Method of Suspending Nozzle Line.

Extreme care should be taken to see that the posts are in alignment, and also to see that the anchors supporting the end of the posts are installed firmly and permanently. The end posts should be attached to the anchors by means of two No. 4 galvanized wires or ¼ in. stranded cable in which turn buckles are used.

It is not necessary to bring the suspension cable through the end posts to the ground; but the suspension cable can be firmly attached to the end posts and these end posts can be supported to the anchor by means of two heavy wires, in each of which is inserted a turnbuckle.

When a number of lines are erected with the end posts in a row, a single anchor cable for each end post can be used, this cable being placed directly in line with the post and the sprinkling pipe. To prevent side motion, a cable or wire is stretched between the series of end posts, and fastened to the top of each post. Each end of this cable is anchored at right angles to the single anchor above referred to and in line with the cable itself.

For use in connection with its overhead irrigation systems the Skinner Irrigation Co. has developed a water driven device which automatically oscillates the sprinkling line. The primary advantage of this arrangement is that it entirely eliminates labor. It is necessary only to start the pump or turn on the water. This not only supplies water to the sprinkling line, but starts the automatic oscillation of the nozzle lines without further attention.

The general principle on which the automatic hydraulic oscillator operates is that of a reciprocating piston. A small hydraulic cylinder is set at one end of the field. A cable is attached to the piston working in this cylinder. The cable is passed over a pulley wheel, extends through the field and is attached to the handle of the union on each sprinkling line. The cable at its opposite end passes over another pulley wheel and is there attached to a weight.

The cylinder acts simply as a water motor. The feeding of the water into the cylinder forces the piston down. When it reaches its extreme downward position, the valve is automatically thrown by a balance and the weight at the opposite end of the field gradually descends, pulling the piston up and discharging the water. At the extreme up stroke, the valve is again thrown and the piston again descends. Since the union handles are connected to the cable, the travel of the cable oscillates the sprinkling line back and forth. The speed of the oscillation is controlled simply by the adjustment of the opening in the valve. The speed varies somewhat with the pressure, but the valves can be so adjusted that each travel of 120 degrees will consume any period of time from 1 to 30 minutes. With the valves once properly adjusted they will need no further attention unless it is desirable to change the speed of the oscillation. This change is easily made.

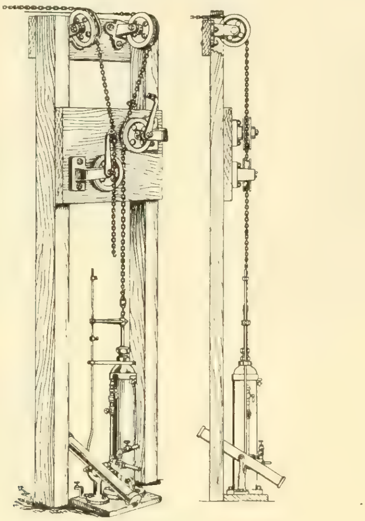


Fig. 2. Arrangement of Hydraulic Oscillator.

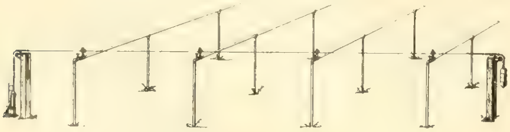


Fig. 3. Hydraulic Oscillator Operating Four Lines.

The hydraulic oscillator is designed for plants of less than 10 acres. In an installation put up with a reasonable degree of accuracy it will easily operate 2 acres at one time. It is in successful operation on a number of plants, which are well put up, oscillating more than 3 acres. It is possible also to install the oscillator in the center of a field of 8 or 10 acres, operating one-fourth of the field from the oscillator at one time.

It is stated that as an average example of costs, the oscillator and turning equipment complete for a 2-acre plot consisting of four lines 420 ft. long, arranged as shown in Fig. 3 would cost about $85. The equipment for additional similar plots operated from the same oscillator would cost about $30 each. Thus two of these plots making a total of 4 acres would require total equipment costing $115. The price per acre varies from $20 to $45 for the complete automatic equipment. If the oscillator can be arranged to turn three or four similar units alternately, the acre cost frequently falls below $20.

The foregoing matter refers specifically to the Skinner system of irrigation. This information was obtained from bulletins issued by the Skinner Irrigation Co. of Troy, O.

THE OPERATION OF HIGH PRESSURE FIRE SERVICE SYSTEMS.

Some interesting data on the operation of the high pressure fire service systems of Philadelphia, Baltimore, New York and Cleveland are given in a recently issued special report of the Committee on Fire Prevention of the National Board of Fire Underwriters. The following matter is taken from this report:

Philadelphia.

In 1902 a portion of the congested value district was protected by a high pressure pipe line supplied by fireboats and in 1904 a pumping station was put into service to supply the system. In 1910-11 a second pumping station was built to supply a distribution system then being built for the protection of the high value manufacturing district north of the congested value district. This new system is connected to the original distribution system by two 20-in. mains and the new station was first put into service in 1912.

Until 1913 the maintenance and operation of the system was by the Bureau of Fire, under supervision of the Director of Public Safety. The system was not used unless a fire in or near the area protected had assumed unusual proportions, although pumps were started and pressure raised for all alarms in the protected area.

In 1913 the maintenance and operation of the two systems was put in the hands of the Bureau of Water, which is under the control of the Director of the Department of Public Works; an experienced engineer was placed in charge.

There had been no uniformity in regard to the pressure carried for fires up to this time, when, after a study of the conditions, it was decided to raise the pressure at the Race St. station to 175 lb. upon receipt of an alarm and to carry 150 lb. at the Fairhill station. The latter station is somewhat higher than the major portion of the protected area and the pressure throughout the system is about 30 lb., and in some places 45 lb., greater than that carried at the station. An automobile, loaded with necessary tools and wye-connections and manned by a chauffeur and two line walkers, responds to all alarms within the area protected by the Race St. station; the Fairhill system is divided into two sections, each served by a similar crew. Upon arrival at the fire grounds the line walkers prepare the most convenient hydrant for service by removing caps, opening main valve and attaching a fitting to which three lines can be attached to the outlet more remote from the fire. In the meantime the fire department generally gets 2½-in. lines into service from fire engines supplied from domestic hydrants. The line walkers operate additional hydrants if necessary, co-operate with the fire department and keep in touch with the pumping station in operation, requesting additional pressure if so directed by the fire department; they also notify the pumping station of the number and size of hose lines in service and those being laid, so that additional pumps can be started in advance of the requirements.

Reference to Table I shows that the high pressure service in the congested value district is used at about one fire in 6 alarms received, and that for an average of a little over one-third of the working fires an increase in pressure above 175 lb. has been requested by the fire department, and that occasionally pressures of 250 to 300 lb. have been needed to adequately supply large and powerful streams.

The entire capacity of the Race St. station, 9,100 gal. a minute, has been called into service on 4 separate fires since 1912, and, in addition, fire engines were in operation.

In the Fairhill system, which protects an area in which the factory buildings are much lower than those found in the congested value district, it has been necessary to raise the pressure at the fire grounds to 200 or more pounds at 15 out of 54 fires at which the system was used, and on two occasions a pressure in excess of 250 lb. was needed. No fire has yet required the Fairhill station to deliver more than 50 per cent of its rated capacity, or about 6,000 gal. per minute, but fire engines are always operated in conjunction with the high pressure system.

The service records of the Race St. station show that the greatest reduction in capacity due to pumps being out of service has been 15 per cent, when one large and one small pump were out of service at one time. The entire station, however, has been out of service because of the failure of the single 20-in. discharge line; the Fairhill station served the congested value area while repairs were being made.

At the Fairhill station the maximum reduction due to pump or engine trouble has been one pump, or 10 per cent of the station capacity, but one-half of the station has been out of service because of repairs on a master relief valve which controls one-half the pumps; blank flanges have been ordered, so that this cannot occur again.

TABLE I.—SERVICE RECORD OF RACE STREET AND FAIRHILL HIGH PRESSURE FIRE SERVICE PUMPING STATIONS, PHILADELPHIA, PA.

				Number of fires at which										
						The following pump capacities were required								
Philadelphia.	Year.	Number alarms in H.P.F.S. district.	H.P.F.S. was used	200 pounds or more was carried.	250 pounds or more was carried.	1,200 g. p. m. 13% total.	1,550 g. p. m. 17% total	2,750 g. p. m. 30% total.	3,950 g. p. m. 43% total	5,150 g. p. m. 57% total.	6,350 g. p. m. 70% total.	7,550 g. p. m. 83% total.	7,900 g. p. m. 87% total.	9,100 g. p. m. 100% total.
Race Street Station..	1912	....	22	14	8	....	6	3	5	2	..	1	....	3
	1913	....	20	8	3	....	13	4	2	..	1	....	..	....
	1914	181	39	13	4	4	22	5	1	2	..	2	2	1
	1915	181	29	12	0	1	18	7	....	2	1	...	....	...
(To Nov. 1)	1916	157	24	9	1	2	15	4	3	....	.	..	..	.
				200 pounds or more at fire grounds.	250 pounds or more at fire grounds.	1,200 g. p. m. 10% total.	2,400 g. p. m. 19% total.	3,600 g. p. m. 29% total.	4,800 g. p. m. 39% total.	6,000 g. p. m. 49% total.				
Fairhill Station	1912	35	4	2	1	....	2	....	1	2	.	...	...	...
	1913	91	10	4	1	4	4	2	....	...	..	...	....	..
	1914	128	18	6	....	8	6	.	1	.	.	....	....	....
	1915	206	5	0	0	2	3		....	.	.		....	.
(To Nov. 1).	1916	227	17	3	0	8	7	2	....	..	....	..	..	..

Baltimore.

The high pressure fire service system was put in service in 1912. It is operated and maintained by the fire department. The station is operated by steam; a pressure of 100 lb. is maintained on the distribution system by a small pump and upon receipt of an alarm from the district served one of the three large pumps is started and pressure is raised to 250 lb. The pump governors are so set that each pump has a capacity of about 5,000 gal. a minute. The pressure required on the individual hose lines is supplied through regulating valves in the portable service heads of the hydrants. It has never been necessary to communicate with the station from the fire grounds and the pressure of 250 lb. has proved ample up to the present time.

During 1912 there were 55 alarms received from the district and water was used on 14 fires. During 1913 there were 98 alarms in the district and water was used at 46 fires. Two pumps were used at one fire in September and at one fire in December. During 1914 there were 136 alarms in the district and water was used on 61 fires. Two pumps were used on 5 fires during the year. During 1915 there were 134 alarms in the district and water was used on 12 fires. Two pumps were used on 3 fires. During 1916, up to Nov. 1, there were 62 alarms from the district and water was used on 4 fires, at 2 of which 2 pumps were used.

No means are provided for measuring the water discharged from the station, but if the speed of the pump or pumps in operation indicates that they are reaching their capacity another unit is started. From the operating records it would appear that not more than 10,000 gal. a minute has been used from the system on any fire since it was put in service, but at all fires in the district protected fire engines also respond.

The regulators on the hydrant heads carried by the four high pressure companies can be operated from full closed to wide open; those carried on other apparatus have a stop which does not permit them to be opened beyond a point giving 100 lb. on the hose lines supplied; the stops (on these chucks) can be removed if a greater pressure is ordered by commanding officers.

During 1915 a pressure of 200 lb. or more was carried on four 3-in. lines at 2 fires in January; in February, 200 lb. was carried on a 3-in. line, 700 ft. long, used on a fire near the boundary of the distribution system; in August, 200 or more pounds was used on 3-in. lines supplying wagon pipes, 1 water tower and 2 deluge sets. In 1916, at two simultaneous fires in March and twice in August, a pressure of 200 lb. was used on lines supplying large streams. With the exception of one of the fires in August, 1916, the fire areas on which lines carrying 200 or more pounds were used were below the sixth story.

Service records of the equipment show that one of the large pumps was out of service for several months in 1916, but there appears to have been no time when two units were out of service at the same time; when ordinary repairs are necessary plans are made in advance, so that work may be carried on as expeditiously as possible, and to date, with the above exception, no unit has been out of service more than one day.

TABLE II.—SERVICE RECORDS OF GANSEVOORT AND WEST STS. AND OLIVER AND SOUTH STS. HIGH-PRESSURE PUMPING STATIONS, NEW YORK, N. Y., JULY 25, 1908, TO OCT. 25, 1916, WHEN TWO OR MORE PUMPS WERE IN OPERATION.

	Number of fires requiring										
									Pressure of		
	2 pumps in operation.	3 pumps in operation.	4 pumps in operation.	5 pumps in operation.	Less than 10,000 gal. per minute.	More than 10,000 gal. per minute.	More than 15,000 gal. per minute.	Maximum discharge, gal. per minute.	125 lb. or over.	150 lb. or over.	200 lb. or over.
Gansevoort St..	47	8	2		[illegible]	[illegible]	[illegible]	16,200	19	[illegible]	
South St.	40	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible]
Both stations				1			1	32,700	[illegible]	1	

New York.

The Manhattan high pressure fire service, covering the lower part of the island, was put in service in July, 1908. The distribution system is served by two pumping stations, each equipped with 6 centrifugal motor-driven pumps rated at 3,000 gal. a minute at 300 lb. pressure. The system is operated as a part of the Department of Water Supply, Gas and Electricity, and is in charge of an engineer of this department.

Upon receipt of alarms from the protected area a pump is started and pressure raised to 125 lb. Pressure is increased if the commanding officer at the fire grounds so orders through a special high pressure fire service signaling system. Additional pumps are started as the Venturi meters indicate that the discharge is approaching the capacity of those in service.

One pump operating at 125 lb. pressure is all that is required in the large majority of cases to control the fire, but in the past 8 years there have been 104 fires that required two or more pumps to be in operation at the same time, and in most of these instances an increased pressure, sometimes as great as 300 lb., was called for by the fire department.

Table II shows the service records of both stations. Of the buildings in which fires occurred which required a pressure of 175 lb. or more, the highest was a 14-story brick and steel building, 40 by 125 ft., at 395 Broadway, where a pressure of 175 lb. was required, and the next highest was a 10-story brick and steel building, 50 by 100 ft., at 80 Broadway, where a pressure of 300 lb. was ordered. In the remaining cases buildings did not exceed 8 stories in height, yet pressures of 200 lb. and more were carried to develop large streams sufficiently strong and penetrating to cope with the fires, which proves by fact the theoretical need of pressures of 200 lb. and over in a system of this kind, if effective fire fighting is to be obtained in buildings of even moderate height when the fire has gained considerable headway and is threatening to involve the whole building and perhaps communicate to adjoining buildings.

TABLE III.—SERVICE RECORD OF PUMPS, HIGH-PRESSURE FIRE SERVICE, NEW YORK.

Number of days during which one or more pumps were out of service.

	Gansevoort St. Station. No. of pumps.			South St. Station. No. of pumps.		Both stations No. of pumps.				
Year.	1	2	3	1	2	1	2	3	4	5
1908	9	1	2	24	41	29	32	8	1	1
1909	77	9	1	61	8*	100	23	2	1	3*
1910	153	27	...	34	...	186	31	3	...	...
1911	195	102	2	179	19	44	167	109	7	...
1912	131	145	17	220	2	107	117	93	19	...
1913	145	1	...	118	...	59	103	...	...	...
1914	17	4	...	9	...	24	5	...	...	...
1915	145	37	4	173	...	107	119	17	2	...
1916	120	...	...	51	2	95	38	...	...	...

*Including two days when 6 pumps were out of service from flood in basement.

For the two years prior to October, 1916, the New York fire department had not been called upon to fight a fire where it was found necessary to call for a pressure in excess of 150 lbs., yet on the evening of Oct. 25 two simultaneous fires occurred in two 7-story loft buildings within two blocks of each other, and one of the fires gained such rapid headway that a pressure of 200 lb. was required to develop streams of sufficient size and strength to cope with the existing conditions. Likewise, these fires required the operation of 4 pumps and, at their height, 15,500 gal. a minute were being delivered through hose lines.

The electric power for operating both stations is furnished through underground cables sufficiently in duplicate to preclude the possibility of failure of the supply, and the contracts which have provided for the supply have always contemplated and provided for the possible operation of all twelve pumps at one time. The contract for 1916 provides that the city pay the New York Edison Co. 1.50 ct. per kw. hour for actual current used, and that the company stand ready to furnish 6,500 kw., for which the city pays a yearly standby charge ranging from $34,656 to $75,240, depending upon the amount used at any time in excess of 2,800 kw.

TABLE IV WORK PERFORMED BY HIGH-PRESSURE FIRE SERVICE PUMPING STATION, CLEVELAND, OHIO.

		Number of fires at which					
					Pressure used.		
Year.	No. of alarms from district.	Water was used.	Pumps in use. 1	2	200 lb. or or more.	250 lb. or or more.	Maximum water used, gal. a minute.
1914	181	6	4	1	2	1	3,000
1915	198	8	4	1	5	0	3,800
1916 (Oct. 1.)	140	4	2	2	0	0	5,000

Thus provision is made to operate the entire capacity of both stations if occasion demands.

The service records of the mechanical equipment in the two stations show that the entire capacity is required to provide proper reserve for pumps out of service for repairs.

In 1911 and 1912 extensive repairs were made to the motors, but the records in general show the ordinary service conditions for equipment of this class and service.

Cleveland.

The Cleveland high pressure fire service pumping station commenced to serve the distribution system in 1913.

The pumping equipment consists of four 2,500-gal. motor-driven centrifugal pumps. Current is supplied from the municipal plant through five cables in one conduit. During the past 20 months there have been 10 instances of 1 to 63 minutes' duration when power was not available; at other times the municipal plant has been loaded to capacity and some of the load would have had to be dropped to operate the pumps.

The pumping station is under the supervision of the fire department. Table IV shows the service record of the system for the past 3 years. At all these fires the regular response of fire engines was also available.

SHORE PROTECTION SYSTEM FOR HARRISON COUNTY, MISSISSIPPI.

A shore protection system involving several interesting features has been designed for the coast line of Harrison County, Mississippi, by Hobart D. Shaw, City Engineer, Gulfport, Miss. The system is described by Mr. Shaw in the December Proceedings of the Louisiana Engineering Society, from which the following notes have been taken:

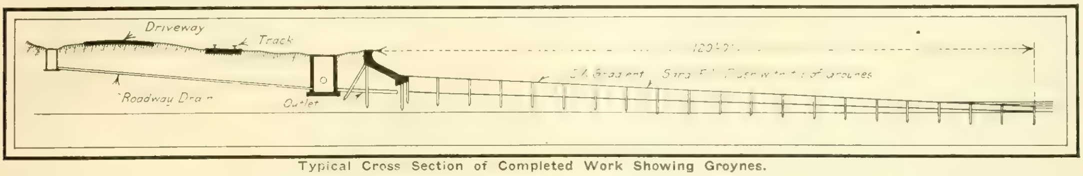
The surveys consisted of a transit base line run at convenient angles along the fore-shore in the customary manner. To this line were "tied in" all the property lines, car track and other physical structures that might be involved. Along this line level readings were taken, and on each side of it cross-section readings were taken extending sufficient distances and at necessary intervals to enable the plotting of a contour map and comprehensive cross-sections of all the territory affected. At distances of about 500 ft. stadia readings were taken into the water to determine the approximate gradient at which the bottom of the gulf receded from the shore line, or water's edge. This gradient was found to vary from 0.4 per cent to 1.0 per cent.

The data thus collected were plotted, so that every relation between cause and effect would be partially apparent. In other words, a complete contour map was made which shows contours from 0 to 18 ft., the 0 being the U. S. Government datum.

In addition to the general surveys sufficient tests were made to determine the angle of repose of the average beach soil in its dry state and when possessing its normal moisture. In the first case this angle was found to be 29° 26′ and in the latter 39° 48′. The capillary attraction of this soil, or what might be more properly termed the resistance offered by the sand medium to the flow of the underground water toward tide level, also was determined. It was found that under average conditions and at a distance of 100 ft. from the water's edge the ground water stands 6.3 ft. above the datum plane. The height of the water does not fluctuate with the variations of normal tides. The importance of this data is obvious when it is remembered that the presence of groundwater in the fine sand of which the beach soil is nearly altogether composed means running quicksand and hydraulic pressure in case of excavations.

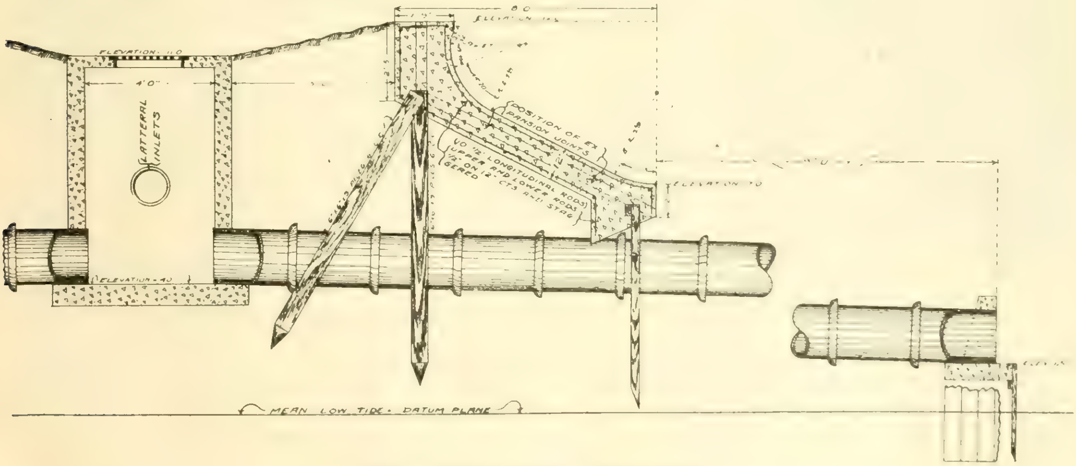
In the design Mr. Shaw was confined within two arbitrary limits: First, the evident fact that the value of the property to be protected would permit of an expenditure of only approximately $10 per lineal foot; and, second, the area on which the proposed protection must be located in order to keep within the first limit.

For the purpose intended groynes of very simple design appeared to be sufficient. In arriving at the details of construction and arrangement Mr. Shaw was governed by the following factors: First, the regular tides produce a shoulder along the edge of the water varying in height from 3 to 4 ft. above mean low tide, or the datum plane. As this shoulder appears to remain intact under normal conditions, and is even found to exist after the storms, it was concluded that the water does not assume any aggressive action until after the elevation of 4 ft. is passed. Second, the storms have a tendency to leave a fore-shore on a gradient between 5 and 6 per cent, provided that the littoral drift does not counteract this tendency. It was believed, therefore, that it would be a feasible scheme to construct a slope on the first named gradient if the topographic conditions would permit, and secure the maintenance of this slope by the use of groynes. In order to do this, however, a vast amount of filling would be required, and the cost of this filling would exceed the possible expenditure. It also was not possible to construct a system of groynes and depend on the accretion to fill the spaces between them, because there is no accretion worthy of notice. Hence, whatever space there may be between the tops of the groynes and the natural surface must be filled at the outset; and when so filled the position of the groynes should offer sufficient resistance to the littoral action to maintain the surface at the desired plane. The spacing of the groynes was done in accordance with a "rule of thumb" which has apparently been evolved from long practice rather than from any particular law of mechanics. This rule is: make the spaces between the groynes equal to their length. It has been found to be satisfactory, and is therefore generally used.



Typical Cross Section of Completed Work Showing Groynes.

Inasmuch as it would be too expensive and otherwise impractical to construct a slope with the necessary groynes to maintain it to the required elevation, Mr. Shaw found that a retaining wall was the most adaptable method of overcoming this obstacle. The wall as designed is to act both as a retaining wall for the earth behind the vertical section thereof and also as a slab to protect the upper portion of the foreshore from the force of the wave impact and littoral erosion. It will be observed that the square piles will serve, under normal conditions, as anchors, and in case of any washout from the rear they will act as supporting piles. The sheet piling will act also as a support as well as serving to prevent any possible undermining from the front.



Details of Retaining Wall and Drainage System.

In order to relieve the proposed system from the dangerous elements attending the congestion at shore outlets after severe rainfalls, a complete series of outlets of varying dimensions suitable to their respective localities has been provided. In connection with these outlets, lateral drain pipes are contemplated to collect the water and convey it to the outlets.

RESULTS OF NINE MONTHS' OPERATION OF A WATER SOFTENER AT THE PUMPING STATION OF SPRINGFIELD, O.

By S. B. Applebaum, C. E.*

The water works at Springfield, O., is a municipally owned and operated system under the management of Mr. George S. Cotter. The source of the water supply consists of shallow wells about 30 ft. in diameter and 22 ft. deep, located about 4 miles from the center of distribution.

The distribution system consists of a steel standpipe and about 122 miles of water mains ranging in size from 3 in. to 24 in. in diameter. The piping layout is equipped with 1,151 valves and feeds and 830 fire hydrants. There are 3,000 branches metered. The water is delivered to the consumer at a constant pressure of 90 lb. per square inch. Recently Mr. Cotter succeeded in connecting the ends of the distributing lines to complete a loop and thereby equalize the pressure at all points and maintain a fire pressure of 80 lb. per square inch in the business district.

The pumping equipment proper consists of three vertical triple expansion engines, the sizes being as follows: One 12,500,000-gal. pumping engine, 26 in.-48 in.-72 in. by 42-in. stroke, with 26¼-in. plungers, built by the Allis-Chalmers Co.; one 10,000,000-gal. pumping engine, 26 in.-48 in.-72 in. by 42-in. stroke, with 23½-in. plungers, built by the William Tod Co., and one 7,500,000-gal. pumping engine, 21½ in.-38 in.-56 in. by 36-in. stroke, with 20-in. plungers, built by the E. P. Allis Co.

These pumping engines are all equipped with surface condensers which maintain a vacuum of 28 in.

The boiler plant generating the steam for the pumping engines consists of four 125-H.P. horizontal water-tube boilers, built by the Babcock & Wilcox Co. The steam pressure carried is 150 lb. per square inch. The feed water consisted in great part of the returns from the surface condensers, with less than 20 per cent raw make-up water, which was heated in an open heater before being pumped into the boilers. Nevertheless it was the experience of the station that this slight amount of make-up water was sufficient to cause a very hard and heavy deposit of scale in the boilers and their connections. Not only was there the constant labor and expense of turbining out of tubes and cleaning of the boilers to remove this troublesome incrustation, but there was a waste of fuel due to the insulating properties of the scale above alluded to. It was decided to install a water softener. The Zeolite type of water softening plant was selected because it was compact and was guaranteed to produce a neutral non-caustic water which would be of "zero hardness"—that is, containing no calcium or magnesium—and which would therefore deposit no scale, sludge or mud in the boilers of their connections.

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*[illegible] The Permutit Co., New York City.

The Zeolite filter shown in Fig. 1 was installed in June, 1915. The space occupied is less than 3 ft. in diameter by 12 ft. high. It was therefore possible to locate the filter in an odd corner of the boiler room, making a compact installation. The operation of the filter is automatic, in that no chemicals are added to the water. The filter contains an insoluble synthetic zeolite through which the water passes. In the very few minutes during its passage the hardness is completely removed. The interesting feature of the process, however, is that the zeolite is not consumed by the softening reactions and that after 12 hours' service it is restored or "regenerated" to its original condition by immersing the filter bed in a solution of common salt. The cost of operation with salt at $5 per ton is about 25 ct. per day. There is no sludge to dispose of in any part of the process. The salt solution is liquid and is run out to the sewer. The analysis of the raw and softened water is as follows:

Fig. 1—Water Softening Plant at Springfield.

	Raw water. Parts per million.	Softened water. Parts per million.
Total hardness, calculated as $CaCO_3$	299	0
Calcium	163	0
Magnesium	136	0
Alkalinity	238	240
Free CO_2, calculated as CO_2	7	2
Chlorides, calculated as Cl	6	6
Sulphates, calculated as SO_4	65	65
Iron, calculated as Fe	0.1	0.1

After about nine months' operation the original scale in the boilers was completely removed by the use of "zero water." The boilers were then inspected and a two-months' test was run to compare the operation of the clean boilers using "softened" water with the operation during the same months in the previous year when hard water was used. Table I gives the results of the test run and of the corresponding run in 1915 showing the amount of water pumped, the coal burnt and the duty per 100 lb. of coal. These figures are taken from the city records of the log sheets of the station. The quantities of water pumped in 1915 and in 1916 may be seen to be fairly identical so that the element of load factor is eliminated. The cost per ton for the fuel used is higher in 1916 than in 1915, removing the possibility of a poorer grade having been used. In brief this table may be summarized as follows:

In March and April, 1916, 2 per cent less water was pumped with 22.6 per cent less coal than in the corresponding months of 1915, so that a comparative saving in fuel of 21 per cent was obtained. The average duty in March and April, 1915, was 61,800,000 ft. lb. per 100 lb. coal as against 78,200,000 ft. lb. per 100 lb. coal in 1916, or an increase in duty of 26.6 per cent. It is estimated that this saving of about 2½ tons of coal a day returned the investment for the zeolite filter in a period of about six months after the plant was put in operation.

TABLE I.

	March and April, 1915.	March and April, 1916.
Water pumped, total gal	420,932,376	412,551,691
Coal burned, total lb	1,179,798	912,569
Water pumped daily, average gal	6,910,288	6,763,193
Coal burned daily, average lb	19,370	14,983
Duty, millions of ft. lb. per 100 lb. of coal	61.8	78.2
Increase in duty, per cent		26.6

The use of "zero" water has also saved the boiler plant from shut-downs for the purpose of turbining the tubes or of cleansing the pumps, heaters, boilers and connections, to remove the heavy scale which formerly accumulated. The labor and expense of this cleaning as well as the cost of shutting down equipment allowing the investment to stand idle, are also eliminated.

COST OF WELDING JOINTS OF GAS MAINS BY OXY-ACETYLENE PROCESS.

The cost of welding joints of gas mains by the oxy-acetylene process ranges from $1.10 for a turning joint to $2.81 and $2.20 for a ditch joint and stationary joint, respectively, according to data in a paper presented last October at a meeting of the American Gas Institute by Chester Wilde, Engineer of Mains of the Philadelphia & Suburban Gas & Electric Co., Chester, Pa. The ditch joint is one made in the trench; the stationary joint one made above the trench, but without turning the pipe; and the turning joint the one made with the pipe being turned in order to bring the joint to the most convenient point for the operator. Additional cost data from Mr. Wilde's paper follow:

A turning welded joint on an 8-in. pipe may be made in some instances in 20 minutes or it may take as long as 35 minutes, and yet there would be no difference in strength or in its quality as a gas-tight joint. This difference of time may be caused either by the chamfer on the ends of the pipe being very uneven, or possibly due to one or the other of the ends of the pipe which is being welded having for a portion of its circumference an extra thickness of metal.

First, considering an average joint, and taking into consideration only the actual time necessary to make it, the cost will be:

Labor (including operator and helper)	$0.23
Acetylene	.38
Oxygen	.42
Filling iron	.07
Total cost per joint	$1.10

or a total cost per foot of pipe laid (20-ft. lengths) of 5.5 ct.

The above cost being only for the actual time found necessary to make the joint, it will be obvious that, in order to arrive at a more clear understanding of the cost of the weld, the full cost or the time of the operator and helper in other work, such as setting the pipe for the joint, changing tanks, necessary in connection with the actual welding, should be added. This additional charge will increase the labor cost from 23 ct. to 41 ct., making the total cost of the joint $1.28 and the cost per foot of main laid 6.4 ct.

Still further considering the cost in addition to the labor cost necessary for the actual welding, add the labor cost found necessary when laying a main of the size being considered (8 in.) to place the pipe in position for the welder and helper, it will be found that there will be an additional labor cost of 18 ct. per joint, making the total cost of the joint $1.47, or a cost per foot of main laid of 7.3 ct.

The above costs were calculated from 327 joints made by three welders working ahead of the ditch.

Considering now the ditch and stationary joints, it would be found, if the maximum cost of these were taken, that in some instances they would be as high as three times that of the turning joint, depending upon the condition under which it is found necessary for the operator to work. First, considering the ditch joint, the average cost will be about as follows:

Labor	$0.45
Acetylene	1.06
Oxygen	1.20
Filling iron	.10
Total cost per joint	$2.81

The stationary joint will be found to cost somewhat less than the above and will average about as follows:

Labor	$0.30
Acetylene	.84
Oxygen	.96
Filling iron	.10
Total cost per joint	$2.20

From a careful study of these figures it will be at once apparent that every effort should be made to avoid these latter joints, as already shown, wherever possible. The joint in the ditch should only be resorted to when an obstruction compels its use. It will be found in the case of the stationary joint that an average of about fourteen men will be required for each mile of main laid. If good judgment is used and these expensive joints kept to a minimum, the average cost per joint or per foot of main laid will only be slightly increased.

Some engineers have thought that the extra cost of labor for handling the 40-ft. lengths of pipe would more than offset any saving which might be effected due to the reduction in the number of joints made per foot of main laid.

In order to arrive at an intelligent understanding on this subject, the average cost of 128 joints, or practically a mile of 8-in. main, using 40-ft. lengths, was calculated. The average cost, including all labor necessary, in addition to the operator and helper, for shifting the pipe ahead of the welders, showed as follows:

Labor	$0.95
Acetylene	.38
Oxygen	.42
Welding iron	.07
Total cost per joint	$1.82
Total cost per foot of pipe laid	$0.045

Thus it will be seen, by a reference to the maximum cost of a joint made when using 20-ft. lengths under the same conditions, the cost will be 35 ct. less than the joint of the 40-ft. lengths, but that the latter has a much less cost per foot of main laid, the difference in favor of the long lengths being 2.8 ct. These figures, however, do not take into account the possible extra cost due to cartage, which would probably decrease the difference per foot in favor of the 40-ft. lengths to about 2.3 ct.

TABLE I.—COST TO WELD JOINTS

Test No.	Size of pipe. Ins.	Size of tip.	Time to make weld Minutes.	Acetylene consumed. Cu ft.	Oxygen condensed. Cu ft.	Filling iron used. oz.	Cost of weld.
1	1½	6	3	1.25	1.5	0.9	$0.08
2	1½	6	[illegible]	1.0	1.0	0.8	.06
3	2	6	5	2.0	2.25	1.1	.13
4	2	6	3	1.25	1.5	1.0	.10
5	3	6	7½	3.0	2.5	2.45	.19

The foregoing analyses of cost being all for 8-in. joints, it might be of interest to have, as a guide in order to arrive at the cost of mains of sizes from 1½ in. up, the actual cost of making the joints in the smaller sized pipe:

Table I shows these costs arrived at from tests made on joints from 1½ in. to 3 in. The actual time to make 4-in. and 6-in. joints would be about 14 and 20 minutes, respectively; and the cost would be about 55 ct. for the 4-in. and 70 ct. for the 6-in.

These tests show only the cost of labor actually required to make the joint, the costs, including all other necessary labor in connection with the weld, will be governed by the efficiency of the organization.

DEFLECTION TESTS OF UNIVERSAL PIPE.

Exhaustive tests of Universal pipe and fittings have been completed recently by the Underwriters Laboratories of the National Board of Fire Underwriters. The deflection tests are of particular interest. The pipe used in these tests consisted of 14 sections of 8-in. pipe of the 175 lb. class having 2 bolts, 10 sections of special extra heavy 12-in. high pressure pipe having 4 bolts, two sections of 4-in. pipe of the 175 lb. class having 2 bolts, two sections each of 6-in. and 8-in. pipe of the 130 lb. class having 2 bolts, and the necessary caps, plugs, bolts, and washers.

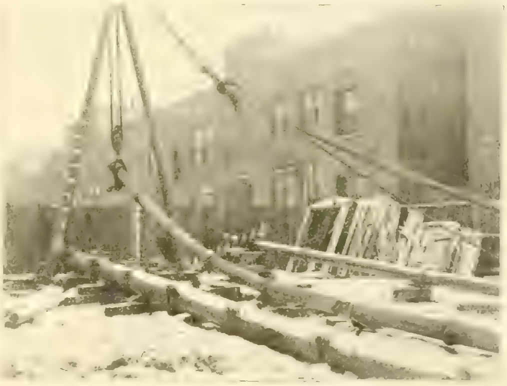

Fig. 1—Test Sections.

Two pipe lines made of the 14 sections of 8-in. and the 10 sections of the 12-in. pipe were installed on blocking above ground in the yard at the laboratories. The 8-in. line was approximately 84 ft. and the 12-in. line approximately 60 ft. in length. Blocking was placed under the piping near each joint and so arranged that the one end of each of the lines was approximately 30 and 26 in. higher than the other ends of the 8 and 12-in. pipe, respectively, and so that the pitch was nearly uniform and the lines practically straight. A block and tackle was attached in turn to the extreme outer or higher end of the lines.

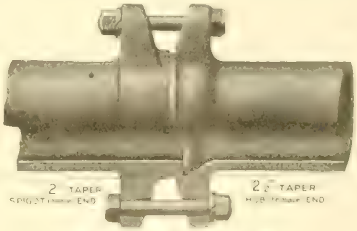

Fig. 2 Joint of Universal Pipe.

The piping was tested to determine the effect of vertical and lateral deflection of the pipe lines while under hydrostatic pressure considerably in excess of the rated working pressures. Deflections considered to be much in excess of those likely to occur in practice were secured by removing portions of the blocking and allowing the pipe lines to gradually settle except at the extreme ends. The ultimate deflection was determined by gradually lifting the outer end of each line until failure occurred.

The 8-in. line was tested first with the bolts in a horizontal plane and then with the bolts in a vertical plane. A hydrostatic pressure of 250 lbs. was maintained in the line, and the line deflected by gradually removing the blocking and by lifting the outer end gradually. In the vertical deflection test the gradual removal of the blocks caused the middle portion of the line to settle until it rested on the ground, so that the line as a whole lay in a reasonably smooth upward curve toward each end. The deflection was greatest at about the middle of the line where it was approximately 30 in. between the ends. The deflection at the joint No. 3 from the higher end was slightly greater than at any of the other joints. No leakage or distress of any kind was apparent during this portion of the test. When the outer end of the line was raised to 5-ft., the first four joints were off the blocks. (See Fig. 1). The maximum deflection was approximately 2.1 ft. between the point where the line rested on the ground and the outer end of the line. The curvature was still reasonably smooth but the joint at each end of the third pipe section had apparently nearly reached the maximum angle without leakage. No leakage or weakness was apparent during this portion of the test. When the outer end of the line was raised to 6 ft., a leak beyond the capacity of the hand pump developed on the under side of joint No. 3. The maximum deflection of the line was approximately 2.35 ft. and the curvature still reasonably smooth. The test was continued until the increased stress at joint No. 4 cracked the hub end of pipe section No. 4. This occurred when the outer end of the line had been raised to 11 ft. without pressure on the line.

When the line was rotated so that the bolts were in the vertical plane the deflection was greatest at about the middle where it was approximately 30 ins. between the ends. The curvature was reasonably smooth. Some of the bolts along the upper side were loose, the depressed contour of the line tending to throw comparatively heavy stress upon the bolts underneath and holding the upper portions of the taper joints tight by the thrust thus exerted along the top. Joint No. 3 was still leaking slightly but no leakage developed in the other joints. When the outer end of the line was lifted 1 ft. a slight leak developed in joint No. 6, joint No. 3 continuing to leak about as before. The deflection was only slightly increased, the curvature remained uniform and no change was noticeable in the condition of the balance of the line. When the outer end of the line was lifted to 2¼ ft. with 225 lb. on the line, joint No. 4 broke off back of the hub.

The 12-in. line was subjected to vertical deflection only in-as-much as the joints are provided with four bolts and the stresses are the same for vertical and lateral deflections. A hydrostatic pressure of 600 lb. was established and maintained on the line, and the line deflected by gradually removing the blocking and by lifting the outer end until failure occurred. The gradual removal of the blocks caused the middle portion of the line to settle until it rested on the ground, so that the line as a whole lay in a reasonably smooth upward curve toward each end. The deflection was greatest at about the middle of the line, where it was approximately 27 in. between the ends. The angle of deflection at joints Nos. 5 and 6 from the higher end was slightly greater than at any of the other joints. The line remained tight until the middle portion nearly reached the ground, when slight leaks occurred at joints Nos. 4 and 6. The aggregate leak was not sufficient to prevent maintenance of 600 lb. pressure until the middle of the line rested on the ground. When the outer end of the line was raised 1 ft. the first four joints were off the blocks. The maximum deflection was approximately at the middle of the line and was about 34 in. between the ends. The curvature was still reasonably smooth. The leakage showed no increase and other conditions were apparently the same. When the outer end of the line was raised to 2 ft. the bolts on the under side of joint No. 5 ruptured both bolts, showing clean breaks without flaws, pressure in line being 600 lb. at time of failure. The deflection was greatest near the middle of the line and was approximately 40 in. between the ends. The curvature was reasonably smooth up to the point of failure.

The two lengths each of the 4, 6 and 8-in. pipe of the present pattern and of current output were tested to ascertain the effect of the elimination of the recesses on the vertical and lateral flexibility of the joints.

Each two pipe sections were placed on blocking and assembled in the regular manner, with the ends capped and plugged. The lines were leveled, a hand test pump connected in turn to the end, the piping filled with water, the air allowed to escape through a pet cock tapped into the cap at one end, and a hydrostatic pressure of 250 lb. to the square inch established and maintained throughout each test.

The 4-in. pipe sections were deflected downward at the middle 3.68 in., when water dripped slowly at the joint. The slippage at the bottom of the joint was ⅜ in. and the angle of deflection from the horizontal was 2.9 degrees, corresponding to a radius of curvature in the pipe of 60.6 ft.

The 6-in. pipe sections were deflected downward at the middle 3.25 in., when the shoulders at the joints were touching at the top of the pipe. The joint did not leak. The slippage at the bottom of the joint was 5/16 in. and the angle of deflection from the horizontal was 2.5 degrees, corresponding to a radius of curvature in the pipe of 68.8 ft.

The 8-in. pipe sections were deflected downward at the middle 3 in., when water dripped slowly at the point. The slippage at the bottom of the joint was ½ in. and the angle of deflection from the horizontal was 2.4 degrees, corresponding to a radius of curvature in the pipe of 71.6 ft. Comparison of the deflection of this pipe with the deflections obtained in the test of the 8-in. pipe having recesses back of the joints on the inside showed no material difference.

The results obtained in these tests, according to the report of the Underwriters' Laboratories, show that the form of the joints and the materials are such that the joints having two bolts permit of marked vertical deflection and very considerable lateral deflection in the line without causing leakage, and that the joints having four bolts permit very considerable vertical or lateral deflection of the pipe line without leakage. Also that the elimination of the recess back of the joints on the inside of the pipe does not materially affect the flexibility of the joints, and indicate that the 4, 6 and 8-in. pipe can be made tight at their rated working pressures when laid to a radius of curvature of less than 100 ft. The results obtained indicate, states the report, that where universal pipe and fittings are properly laid the strength of the parts and of assembly is sufficient to safely withstand the stresses developed by any vertical or lateral deflections that are likely to occur under ordinary conditions of service, and that lines of the pipe and fittings will withstand such deflections without material leakage.

As a result of these tests and other tests the Underwriters' Laboratories recommended to the Fire Council that universal pipe and fittings be made standard for ordinary underground water mains where the working pressures do not exceed those designated by cast figures on the castings, and when installed in accordance with the manufacturer's printed instructions.

Time of Transit Through Panama Canal.—The record for time of transit through the Panama Canal was lowered again on Dec. 17. The steamship Acajutla of the Pacific Steam Navigation Company, bound from Guayaquil to Colon, entered the canal at 12:15 p. m. and dropped anchor in the harbor at Cristobal at 6:35 p. m., thus making the transit in 6 hours and 20 minutes. This is five minutes less than the best previous time. The starting and ending point at Balboa is the outer end of the buoyed channel. At Cristobal it is wherever the ship docks or drops anchor, or a point opposite the end of the mole if she passes without stopping.

THE NATURE OF COLOR IN WATER.*

Color in water in large part exists in the form of colloidal suspensions of ultra-microscopic particles, or "suspensoids." These particles carry a positive or negative charge, depending on the water, and varying in different water. Color in water cannot be said to be either positively or negatively charged, but may be either one or the other. Some of the color may be due to colloidal emulsoids and to neutral salts in true solution.

These charged particles are of such minute dimensions that if allowed to remain quiescent under the influence of gravity alone they would remain suspended for very long times. Being similarly charged, they tend to mutually repel each other and remain in suspension indefinitely, a tendency which is strengthened by conventional temperature currents, wind, etc.

Since these particles carry an electric charge, and are in colloidal suspension, they obey the laws of cataphoresis when an electric current is sent through a colored water. The particles are attracted to the electrode of opposite sign from the charge which they carry. There they are discharged, flocculate and precipitate, with consequent reduction in color of the water. This type reaction may be, and often is, modified by electro-chemical reactions, the reaction being theoretical only in those waters having little alkalinity or iron content.

When an acid is added to a colored water the color migrates to the negative electrode. When a base is added the color goes to the positive electrode.

Decolorization in General.

Sand filtration has been found inadequate for the removal of color from highly colored waters. The degree of removal is very variable, depending on the water and the nature of the sand. A pure quartz sand will remove little color, while sands containing much iron, aluminum or manganese remove a large proportion of color. It is evident that the presence of iron and allied elements in a sand has an important effect upon the capacity of that sand for color removal. In general, experiment has shown that about one-third the color in water can be removed by filtration through sand. That more color cannot be removed may be explained on the hypothesis that the colloidal particles of which it is composed are so extremely fine as to pass in large measure through the smallest capillary pores in the sand. It is possible also that the color colloids removed by filtration are of opposite charge to the filtering medium. The color not removed may not have come in contact with the filter materials or may carry the same electrical charge.

By Flocculation with Electrolytes.

This is perhapes the most general method of clarifying colored or turbid waters. Either alum, or ferric hydroxide and lime, are commonly used as coagulants. The general principle of these reactions upon the basis of the colloidal theory have been explained at length. To summarize, it may be said that where most successfully used the action depends upon the discharge of a negative color colloid by the positively charged ion of the coagulating agent and the positively charged hydroxide which is formed. The consequent neutralization of the charged color colloids results in flocculation, precipitation and decolorization. This process is materiallly aided by the mechanical removal of the color colloids by the hydroxide floc which is formed.

When clarification is obtained with difficulty the reason is frequently that the color colloids in the water bear a positive charge. Hence they are not discharged by the positive elements set free by the coagulating agent. Under such conditions the removal of color is supposed to be essentially a mechanical process resulting from the enmeshment and straining out of the color colloids by the precipitated hydroxide floc.

It is well known that a high alkalinity frequently causes difficulty in color removal. This is explained by the fact that the elements causing alkalinity are negatively charged. If, then, the color also be negatively charged, a correspondingly greater amount of positively charged coagulations and hydroxide will be necessary to cause neutralization and precipitation of the color.

By Storage.

It has been a favorite pastime for certain engineers to enthuse over the removal of color in water consequent upon storage for long lengths of time in large reservoirs. This removal is by them ascribed to the bleaching action of the all-beneficent sunlight, which kills bacteria, removes color and acts generally as the panacea for all water supply ills.

That waters do become decolorized by storage is undisputed. It has been shown that bleaching by sunlight is capable of removing color from water, but the writer doubts the competency of this process to explain the considerable color removal in reservoirs. If, as has been suggested in the foregoing statements, the color in water is largely due to particles in a colloidal state, the precipitation of such particles by storage is largely a matter of electro-statics.

The various streams tributary to a reservoir doubtless carry color particles having different charges. There is also more or less sediment in water, which generally is negatively charged. The mixture of all these variously charged particles in the reservoir probably tends to discharge certain of them, with consequent precipitation and decolorization.

Such, however, the writer believes to be only a minor cause of decolorization by storage. It was early shown by Hollis and later by Whipple that the increase in color with depth in reservoirs is due primarily to the condition of the iron content. That at depths the iron is reduced and taken into solution, that upon rising to the surface in the spring the iron is oxidized and adds to the color. That stagnation or storage will bring about an increase in color of the lower layers of the water which, given proper conditions of wind and temperature, may affect the upper layers, has been well shown by Whipple.

Notwithstanding this, there is in many reservoirs a decided decrease in color. What, then, is the cause of this decolorization, and how may it be explained by the colloidal theory? It seems probable that the iron content is the most important factor in this decolorization. Iron is important in sands for removing color; is a direct precipitant in the case of addition of electrolytes; is the factor upon which color removal by bleaching depends, and is the direct cause of color at the bottom of reservoirs. **In short, iron is probably the chief element influencing the presence and removal of color in water.** The iron does not probably exist in any such simple condition as the ferrous or ferric state. The iron content in color is supposed to exist in the form of certain organic compounds that are in colloidal state, chemical compounds of extreme complexity. Due to many processes, of which oxidation and electro-static neutralization by other colloids are the most active, iron is brought into the ferric state, in which case it exists as a hydrosol and will be precipitated by clay or any other positive colloid. Otherwise some slow chemical change is brought about so that the complex iron suspensoid is broken up into constituent particles which may carry opposite charges and so mutually precipitate each other, or which may be discharged by other differently charged colloids present in the water.

In general it may be said that most coloring matter in water, whether due to iron or not, is charged; and that the color suspensoids mutually repel each other, tending to maintain their suspensoid phase. In large bodies of water, however, agitation by convectional and wind currents, oxidation, algae growths, etc., all tend to bring about contact between the color suspensoids and other colloidal substances in the water, many of which bear an opposite charge. There will tend then to be discharge and neutralization. The particles will then flocculate and precipitate and a reduction of color will be apparent. It has long been noted that when certain turbid streams in the West carrying clay in suspension come into confluence with highly colored, but clear, rivers there is sometimes a reduction in both color and turbidity in the effluent stream. This is readily explained on the hypothesis advanced above, if the color and turbidity bear opposite charges.

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*From a paper by Thorndyke Saville, Assistant in Municipal Administration, Harvard University, presented Dec. [illegible] before the New England Water Works Association. Mr. Saville's paper, of which only the conclusions are here given, is based on studies and investigations carried on in the Laboratory of Sanitary Engineering at Harvard University with a view to proving or disproving the colloidal theory of color in water.

The writer believes, therefore, that not only is color largely due to charged colloidal particles, but that the state and degree of iron in the water is the controlling factor, both as to the permanence of the color and its ease of removal. The latter is undoubtedly much influenced by the alkalinity, a high alkalinity making for difficulty in color removal. The alkalinity increases the negative charges and also possibly makes for electrostatic stability in the complex iron suspensoids. The addition of alkali to water in the same way seems to operate to prevent neutralization of the electric charge on the complex iron suspensoid, thus maintaining the suspensoid condition and preventing flocculation and precipitation.

If any one conclusion is evident from these investigations it is that generalized statements and rules regarding color in water and color removal cannot be made. Every water is in this respect a law unto itself, and the problem of color removal from any given water can be intelligently approached only after detailed study as to the nature and electrical properties of the color in that particular water. But there is great opportunity for further investigation along the lines of colloidal color in water, and that these investigations will undoubtedly prove helpful in the solution of the color removal problem is obvious. Such investigations, however, belong more properly to the water supply chemist than to the engineer. These problems must be approached with an unbiased attitude, for hitherto preconceived ideas have mitigated against a fuller understanding of the subject. While it is probable that all color changes and removal in water are not wholly due to the colloidal properties of the coloring material, yet it would seem that the colloidal theory may be looked to for a more complete understanding of the nature of color in water and for a more satisfactory solution of methods for its removal than now obtain.

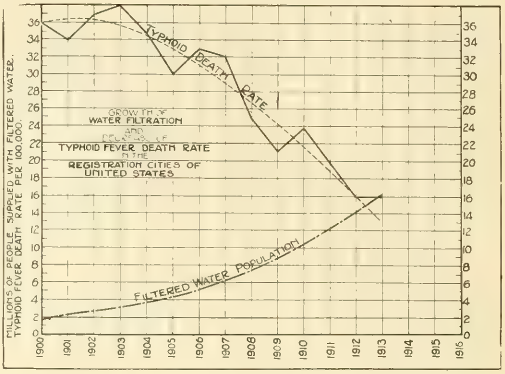
FLOOD PREVENTION IN KANSAS.

Substantial progress is being made on the project for flood prevention on the rivers of Kansas and the adjoining states. Due to the work of the Engineering Committee of the Kansas Flood and Water Congress, organized by Governor Capper something over a year ago, and to the efforts of Senator Curtis, the River and Harbor Bill of July, 1916, provided for an examination by the war department of the flood periods of the Kansas river and its tributaries, the Cottonwood and the Neosho rivers, and for the development of a plan for flood prevention and protection.

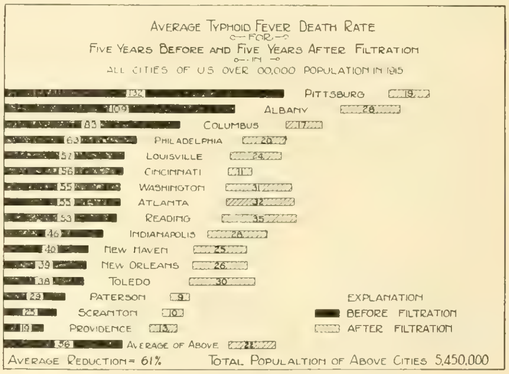
The Chief of Engineers assigned this duty to Chas. McD. Townsend, Corps of Engineers, U. S. Army, Division Engineer, Western Division, with headquarters at St. Louis, Missouri. Colonel Townsend visited the state and held several conferences with the Engineering Committee and other members of the Congress. He then directed Mr. Percival Churchill, U. S. Assistant Engineer, to represent him and to make a personal investigation of the territory under consideration. Mr. Churchill has been in Kansas since the last of November, has travelled over the most of the more important streams, examined obstructions, bank erosions, existing works, many proposed reservoir sites, and has collected much miscellaneous data relating to various phases of the problem. It is understood that he will soon make a preliminary report to Colonel Townsend outlining a future course of action. It is also expected that he will follow this by a thorough examination, based on this preliminary report.

NEW WATER WORKS PROPOSED FOR BAY CITY, MICH.

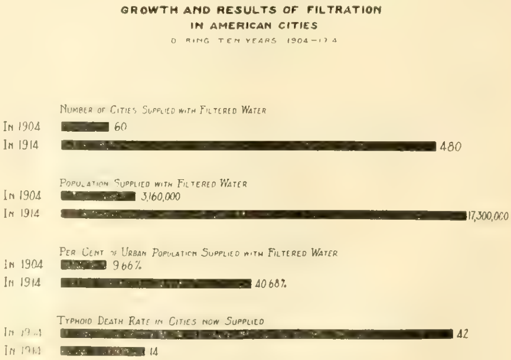
An expenditure of $837,000 for water works improvements for the city of Bay City, Mich., is recommended in a report submitted recently to the city officials by Burns & McDonnell, consulting engineers, Kansas City, Mo. The project, in brief, provides for the consolidation of the two old water works plants, both of which are using water without purification, the installation of new pumps, the laying of a new discharge line to the city, improvements to the distributing system and the erection of a filtration plant. The two pumping plants, under the proposed plan, would be consolidated at the present West Side station. A new intake line slightly larger than the old steel pipe line would be constructed to take water from Saginaw Bay.



Relation of Water Filtration to Typhoid.



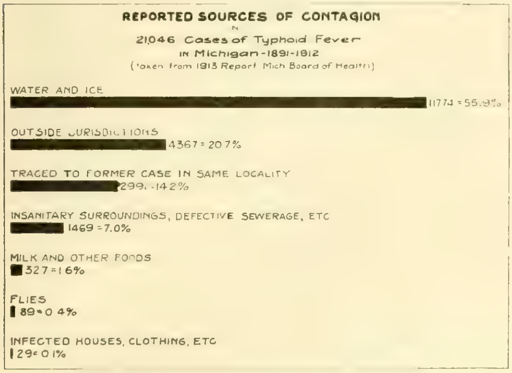
Typhoid Death Rate in American Cities.



Growth and Results of Filtration.

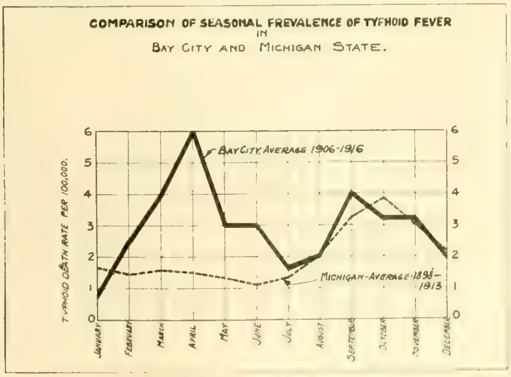
The report of the engineers was prepared primarily with the object in view of making it readable and understandable by the average layman and voter. Much of the engineering data in the report are given in the form of graphical diagrams, charts, tables, etc.

Stereopticon slides have been made of the charts, and in the campaign for the bond issue for the improvements it is proposed to use them to illustrate to the citizens the need of water purification and other improvements. It is planned to hold public community center meetings all over town in order that the voters may be well informed on the question, as it is believed that only a lack of knowledge of the conditions would cause an adverse vote against the project.



Sources of Typhoid Fever Cases in Michigan.

Several of the charts are reproduced with this article. The one showing the sources of contagion in over 21,000 cases of typhoid occurring in the state of Michigan during the period from 1891 to 1912 is of particular interest in showing the large percentage of sources of contagion from water supply and the rather small percentage due to milk, flies, etc. This was prepared from the records of the State Board of Health.



Typhoid in Bay City and Michigan.

Bay City has had frequent epidemics of typhoid fever, one occurring recently with approximately 160 cases, with 10 deaths. The prevalence of typhoid is not surprising when it is considered that out of 40 sewer outlets 38 discharge into the river above one of the water works intakes, one outlet being only 100 ft. from the intake.

The cargo carried through the Panama Canal in the month of November, 1916, amounted to 519,043 tons of 2,240 lbs. The total net tonnage for the month was 436,204 tons according to the rules for measurement of the Panama Canal. The number of ships passing through the canal was 148, which is a drop of seven per cent from the total for October, when 158 ships made the transit.

THE STERILIZATION OF TANNERY WASTE.

The treatment of tannery effluent up to the present time has been limited to the removal of putrescent matter and suspended solids, the aim being simply to prevent nuisance. With the exception of a few investigations made abroad, there has been little recognition of the possibility of the spread of anthrax from tannery wastes. About two years ago an epidemic of anthrax was said to have been caused by the infection of meadows by the waste from a tannery. D. D. Jackson and A. M. Buswell of the Department of Chemistry of Columbia University were requested to investigate the subject and devise means for treating the effluent from the tannery which would prevent the possibility of any further spread of infectious matter. The results of this study were described by Messrs. Jackson and Buswell in a paper presented Dec. 28 for Section D of the American Association for the Advancement of Science, from which the following is abstracted:

The investigation showed that anthrax was at times present in the factory effluent. Accordingly, laboratory experiments were carried out with various disinfectants to determine what was the most effective and least expensive method of treating the sewage.

It was found that both sulphur dioxide and bleaching powder with and without the addition of acid were not effective even in practicable concentrations in killing anthrax spores. Chlorine gas when dissolved in water, however, was found to be a very effective agent. Less than five parts per million of chlorine will kill anthrax spores when suspended in distilled water, 15 parts per million will kill anthrax spores when suspended in the average effluent from contact beds, and 50 parts per million will kill anthrax spores when suspended in tannery effluent which had settled for 20 minutes. In the above cases a time ½ to 2 hours was allowed for the disinfecting action to take place. Tannery effluent from which the coarser portions of hair and fleshings had been removed by a ¾-mm. Reinsch Wurl screen was next tried as a medium for the suspension of spores. When as large a number as 30,000 per c.c. of anthrax spores were suspended in this medium and treated with 50 parts per million of chlorine the spores were not all killed. The surviving spores appear, however, to be completely attenuated. One c.c. portions of several disinfected test flasks which showed 20-60 colonies per c.c. when plated on agar were injected into guinea pigs. In all cases the pigs inoculated with this disinfected effluent survived.

This question of attenuation is of great importance. As in the case of treatment of drinking water supplies, disinfection may not necessarily imply absolute sterilization, but a treatment which renders the effluent non-infectious.

In order to remove the coarse suspended matter two Reinsch Wurl screens were then installed to screen the effluent from the tannery, which amounted to 500,000 gal. per day. These screens remove from 4 to 6 bbl. per day of matted hair, fleshings and small pieces of hide. In other words, the most likely carriers of anthrax spores, the matted hair and fleshings, are removed by the screens. The screened sewage is treated with 50 parts per million of liquid chlorine by means of Wallace & Tiernan's chlorine regulating apparatus.

This complete installation has been in operation for ten months and during that period the raw and treated sewage have been under constant test for anthrax. At no time since the installation was complete was anthrax found in the treated sewage. On four occasions during this period anthrax was found in the raw sewage but not in the treated. On one of these occasions a duplicate set of samples was sent to the Department of Agriculture at Washington. This set also showed anthrax in the raw but not in the treated effluent.

Naturally, the strength of the factory effluent or its absorption of chlorine should be tested in each individual case to insure efficient results.

As far as tannery effluents go, Messrs. Jackson and Buswell feel justified in concluding, as a result of this extensive series of experiments carried out in the laboratory, and corroborated by actual practical tests on a large scale, that for average conditions fine screening, followed by chlorine treatment to the extent of 50 parts per million, is effective for preventing the spread of anthrax from this source.

WATER PURIFICATION IN AMERICA.[*]

At the time of the Hamburg cholera epidemic (1892) less than a half million people in America were being supplied with filtered water. There were small filters at Poughkeepsie and Hudson, New York, which had been built some 18 years before, but the people had not grasped the idea of filtration with avidity, and it seems to have required the Hamburg epidemic to awaken them.

During the same year that cholera was raging in Hamburg it appeared in New York harbor, and this fact spurred into action the officials at Lawrence, Mass., where a plant was quickly built for the purification of the polluted Merrimac River water. This incident really marked the opening of an era of practical accomplishments in America in the purification of municipal water supplies by filtration.

Still, the progress was slow, painfully slow. The writer made a personal study of the water supplies of Japan some 14 years later—in 1906, to be exact—and found that in that what some are still pleased to call "heathen country" a greater number of people were being supplied with filtered water than in the United States. That was only 10 years ago.

Slowly but surely the American people began to see that their rapid growth in population could only be followed by a corresponding increase in the pollution of the lakes and rivers of the country from which the bulk of the public water supplies are drawn. With increasing pollution of the public water supplies must come increasing sickness and death unless those supplies were purified before use. And so the practice of filtering the water supplies of our cities and towns began to grow rapidly, the decision to adopt filtration being hastened by the increasing death toll from that commonest of water-borne diseases, typhoid fever, and by the profitable example of other communities similarly situated who had minimized their water-borne death rate by filtration. More and more cities, convinced by the experience of others, adopted filtration.

Starting at the time of the Hamburg epidemic, less than half a million people in this country were supplied with filtered water. Eight years later, in 1900, less than 2,000,000 people were being so supplied. Between 1900 and 1910, however, municipal water filtration showed a wonderful growth, and in 1910, or six years ago, nearly 11,000,000 people in this country were receiving filtered water. At this date a careful census shows the total number of filter plants in operation in the United States to be 616. The total population of the communities supplied from these plants is between 18,000,000 and 20,000,000. The total daily filtering capacity of these sixteen water filtration plants is 2,261,142,000 gal., or enough to give each inhabitant of the United States 30 gal. of filtered water per day.

Since 1910, therefore, the progress in municipal water filtration in America has been very marked. In the last six years the population so supplied has increased 62 per cent and the total capacity of filter plants in operation has increased 78 per cent. One-third of the total population of the United States supplied with filtered water at this time is located in the states of New York, New Jersey and Pennsylvania. In New York state alone there are 44 municipal water filtration plants. In the last six years municipal water filtration has increased in the state of New York by 125 per cent.

What have been the results of such tremendous increases in the practice of water filtration in America? Typhoid fever is the most common water-borne disease in this country. Fourteen years ago 2,700,000 people in the United States were being supplied with filtered water. Now 17,500,000 people are so supplied. Fourteen years ago the typhoid fever death rate in all the registration cities of the United States, whether they had filtration or not, was 36 per 100,000 population living; now it is 14, or 61 per cent, lower. This means that in every 100,000 people the lives of 22 are saved each year. Among the 17,500,000 people now supplied with filtered water this would make a grand total of 3,850 lives saved each year.

The plain, unvarnished fact is that 20,000 people in this country still die each year of typhoid fever, and that 300,000 people suffer from it. In each decade one in every 33 people in this country has typhoid fever. Now, typhoid fever is a thoroughly preventable disease. No one need have it. It is only caused by taking into the mouth the specific germ, and, utterly distasteful as the statement is, it must be pointed out that the germs so enter the mouth only with the excrement of another human being. It is in this way that a water supply which contains the sewage of human beings causes typhoid fever among its consumers.

What has New York state done to minimize typhoid? Among other things it has undertaken, through its Health Department, to exercise a benevolent control over the public waters of the state. One net result is that in the last 10 years the typhoid fever death rate in New York state has been reduced by 69 per cent, from a death rate of 23 to the present rate of about 7 per 100,000 population. The present population of New York state is, roughly, 10,000,000, consequently this reduction in the typhoid fever death rate means that there are 24,000 fewer cases of typhoid illness and 1,600 fewer typhoid deaths each year than there were 10 years ago. The saving in vital capital thus effected amounts to the stupendous total of $12,000,000 annually, or $1.29 for each inhabitant of the state.

Water filtration costs on an average throughout the United States about 40 ct. per person per year, or something less than 1 ct. a week. These figures are sound and the financial records of hundreds of cities bear them out. And so if a city of 20,000 people spends each year 40 ct. per capita for purer water, and thus each year prevents a single death and the attendant 15 cases of illness from typhoid fever, it will come out even financially and increase its self-respect into the bargain.

The experience of two of our big cities, Pittsburgh and St. Louis, is worthy of special mention. Pittsburgh takes its water supply from the Allegheny River, which is now and for generations has been foully polluted. The average typhoid fever death rate prior to 1910, when the water was first filtered, was over 100 per 100,000 inhabitants. In the 6 years that they have had filtration the rate has averaged 7 per 100,000. In a population of 500,000 people this means an annual saving of 7,000 cases of typhoid illness and 465 typhoid deaths each year, and a vital capital saving of $3,500,000 per year. The general death rate from causes other than typhoid fever was reduced by 222 per 100,000 population, or among 500,000 people represents an additional annual saving of 1,110 lives, which at $5,000 each represent an amount of vital capital in the sum of over $5,500,000 annually. Thus pure water saves Pittsburgh $9,000,000 in vital capital annually.

And St. Louis. For years the mixed raw waters of the Missouri and Mississippi Rivers served as the public supply of that city. Later they built large settling basins, coagulated the water, settled it and then sterilized it, and so obtained a clearer water and cut their typhoid fever death rate in half. But ultimately, as is usually the case, they built a filter plant. The very next year their typhoid fever death rate fell from 16.9 to 7.0 and their general death rate from 1,446 to 1,260 per 100,000, reductions of 59 and 13 per cent, respectively.

Notable and well-known water-borns epidemics have occurred in the cities of Lowell and Lawrence, Mass.; Waterville and Augusta, Me.; Burlington, Vt.; Erie and Pittsburgh, Pa.; Cleveland, O.; Chicago, Ill.; Milwaukee,

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[*] Abstract of paper presented Dec. 28 before Section D of the American Association for the Advancement of Science by George A. Johnson, Consulting Engineer, New York City.

Wis.; Minneapolis, Minn.; Kansas City, Mo., and Omaha, Neb. These epidemics occurred during periods ranging from less than 1 year to 9 years, in which time from 1 to 12 district outbreaks occurred in a single city. The total result was over 100,000 cases of the fever and 6,700 deaths, and a loss in vital capital of $50,000,000, or, roughly, 33 times the cost of permanent prevention through filtration of the water supplies. There was no mystery about the cause of these outbreaks. The officials well knew that the public water supplies were polluted, or open to pollution, and that typhoid fever epidemics might occur at any time.

Consider the example set by St. Louis. Fifty years ago that city sent Mr. James P. Kirkwood to Europe to study filtration. Less than two years ago a filtration plant was completed for the purification of the water supply of that city. In the meantime 7,000 of the inhabitants of St. Louis died of typhoid fever, representing a vital capital loss of over $50,000,000.

Look at the record of Pittsburgh. In the 30-year period ending in 1908 the typhoid fever death rate in that city averaged 103 per 100,000, representing a total of 140,000 cases and 9,400 deaths from typhoid fever. This is equivalent to lost vital capital in the sum total of over $70,000,000. At 40 ct. per capita annually pure filtered water would have cost a total of $3,600,000, or about one-twentieth of the loss. Since the municipal filter plant was placed in service in 1909 typhoid fever in Pittsburgh has become almost a negligible quantity. At present the death rate from this disease in that city is well below 10 per 100,000.

The filtration of polluted public water supplies is always followed by a pronounced reduction in the typhoid fever death rate. In northern cities, where the housefly and general unsanitary conditions are not such factors in typhoid transmission as is unfortunately still true of many southern cities, the first effect of water filtration is much more clearly indicated. A few representative examples of this are given in the accompanying table, where the typhoid fever death rates in certain cities before and after filtering the water supplies are given:

	Average Typhoid Fever Death Rate.		Per cent reduction in typhoid fever death rates which followed the filtration of the public water supply.
	Before Filtration	After Filtration.	
Albany, N. Y.	109	28	74
Charleston, S. C.	106	62	41
Cincinnati, O.	56	11	80
Columbus, O.	83	17	78
Harrisburg, Pa.	72	33	54
Hoboken, N. J.	18	13	28
Indianapolis, Ind	46	28	39
Lawrence, Mass.	110	23	79
Louisville, Ky.	57	24	58
New Haven, Conn.	40	25	38
New Orleans, La.	39	26	33
Paterson, N. J.	29	9	69
Philadelphia, Pa.	63	20	68
Pittsburgh, Pa.	132	19	85
Providence, R. I.	19	13	31
Reading, Pa.	53	35	34
Scranton, Pa.	25	10	60
Springfield, Mass.	22	22	0
Washington, D. C.	55	31	43
Wilmington, Del.	35	21	[illegible]
Weighted averages	60	21	65

According to Hazen's theorem, where one death from typhoid fever has been avoided by the use of better water, a certain number of deaths, probably two or three, from other causes have been avoided. The records from 15 representative cities† bears out this assumption in a striking manner, as follows:

Death Rate from All Causes and from Typhoid Fever in Cities Before and After Filtration

Per 100,000 population.	Before Filtration.	After Filtration.
Total death rate	1,870	1,730
Typhoid fever death rate	67	25
Typhoid lives saved		42
Other lives saved		98

While some 18,000,000 to 20,000,000 people in America are now supplied with filtered water, there remain some 34,000,000 people, representing the balance of the present urban population in this country, who are not so supplied. Many of these get their water from pure underground supplies or from surface sources, some of which are only open to a greater or lesser degree to opportunities for contamination. But a large share of these 34,000,000 people still draw their water supplies from sources which are contaminated and which should be filtered.

The writer has figured** that pure filtered water, or water of equal purity, furnished to all of the urban population of the United States would avoid some 45,000 cases of typhoid fever and prevent 3,000 deaths from this disease each year. Assuming that at least two lives would coincidentally be saved from death from causes other than typhoid fever through the substitution of pure for impure water, and from the brief discussion of Hazen's theorem and the accompanying statistics just given it would appear that such an assumption is justified, we have a total of 9,000 lives annually which could be saved each year by providing pure water in all of our cities and towns which now have grossly or slightly impure supplies. The 3,000 typhoid lives and the treatment of the accompanying 45,000 cases represent vital capital in the sum of $22,500,000. If we allow but $3,000 each for the 6,000 lives saved from death from other diseases we have an additional vital capital saving of $18,000,000; and half as much more would be saved in the cost of medical treatment, wages and depreciated vital energy.

In all, then, universal pure water supplies in the cities and towns in this country would save over what is now being saved some $50,000,000 annually in vital capital. The cost of furnishing 110 gal. of pure filtered water per capita per day to 34,000,000 people would cost, at 40 ct. per capita per annum, a total of $13,600,000 annually, or a little more than one-quarter of the saving.

Of course, this comparison is neither exact nor hardly fair, since a considerable percentage of the urban population is now supplied with water so pure as not to require filtration. But the error is on the conservative side, and the figures show that at the very least, at an expenditure of $1 for prevention in the form of pure water, the public health of the country would benefit in the proportion of four times that cost in saved vital capital.

ARTIFICIAL CONTROLS IN STREAM GAGING.

As an essential part of the establishment of satisfactory gaging stations, the U. S. Geological Survey in recent years has attempted the construction of "artificial controls" on small streams whose beds shift. This feature was described by Nathan C. Grover, Chief Hydraulic Engineer, U. S. Geological Survey, in a paper presented Jan. 10 before the Boston Society of Civil Engineers. The paper was printed in the November Journal of the Society, from which the following notes are taken:

These artificial controls are low dams, generally submerged, erected below the gaging stations in such manner as to control the flow past the stations. The essential features of an artificial control are (a) stability, (b) tightness, (c) sufficient height to serve as a control at all stages, (d) sufficient width (on some streams) to furnish a measuring section, (e) crest of such shape as to give a proper degree of sensitiveness to the station, (f) clear channel of approach, and (g) position near the gage.

Permanence of the stage-discharge relation is the principal object sought in constructing an artificial control. The structure itself must therefore be so built that it will be stable at all stages without serious danger of failure by undermining or washing around the end and that the crest will retain its elevation and shape under the severe conditions of abrasion pertaining to streams that carry large quantities of sand, gravel and even bowlders. The conditions for stability are those pertaining to a small dam. Abrasion of crest may be reduced to a minimum by a steel lip placed in the crest of a control. Such lip is most effective if placed near the downstream edge of the crest, where it will serve both to give a free overfall at low stages and to hold a cover of sand and gravel on the upstream slope for its protection.

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†Present Day Water Filtration Practice, Journal [illegible] Water Works Association, Vol. 1, No. 3, p. [illegible]

**The Typhoid [illegible] Am. Water Works Association, Vol. 2, [illegible]

As an artificial control is constructed in order to make possible the collection of a good record of discharge by means of a record of stage, it is essential that practically all the water shall be forced to flow where it will affect the stage. If appreciable quantities of water can pass through or around a control in strata of sand, gravel or other material, the control will not give satisfactory results.

The height necessary for an effective control varies with the size and slope of the stream at the control and the slope and other conditions of bed and banks below. The lower the control and the less the departure from the natural conditions of channel, the smaller will be the effect of running water in tearing down the structure and the cheaper will be its construction and maintenance. The height of an artificial control must be sufficient to prevent its drowning at medium and high stages by the backwater from a secondary and shifting natural control below. The smaller the slope of a stream and the more restricted and tortuous the channel below the control, the greater the height needed for efficiency. A stream of rapid fall below the control offers little chance for drowning of one control by backwater from a control below. The ratings for certain gaging stations shift only in the low-water sections. For such stations artificial controls of sufficient height to govern the stage-discharge relation throughout the range of shift will evidently accomplish the purpose as well as higher controls.

The profile of the crest of an artificial control across the stream will determine the sensitiveness of the gaging station, and therefore the accuracy of the record that can be collected. The greater the fluctuation in stage for a given change in discharge, the less the refinement needed in the record of stage to obtain the desired accuracy in record of discharge. A long, level spillway will create a pool which will fluctuate slowly and in which the stage must be recorded with great accuracy if reasonably accurate estimates of flow are to be made. The crest of an artificial control should therefore rise by steps or slopes from the lowest part, which may be in the center of the channel or near either bank, to the banks at a rate commensurate with the size of the stream and the accuracy of record desired.

The channel of approach should be free from bowlders, debris or vegetation, in order that the artificial control may effectively maintain a permanent relation of stage to discharge at the gage. The control should be placed as near the gage as is practicable and at only sufficient distance from it to insure that the gage shall at all stages be in still water above the share surface slope immediately above the control.

RECORDS OF GROUND TEMPERATURE.

Records of ground temperature covering any extended period of time are comparatively rare. In a paper in the December Journal of the American Water Works' Association Mr. William W. Brush states that he endeavored to find such records, but was able to locate only the ones that are reprinted below. These were taken by Profs. H. L. Callendar and C. H. McLeod of McGill University and recorded in the Proceedings of the Royal Society of Canada for the years 1895, 1896 and 1897.

The experiments were started in 1894 by Professor Callendar and he was later assisted by Professor McLeod. The location selected for the experiment was level ground in a garden where there was turf and loose light brown sand to a depth of 8 ft. 6 in. Below this sand was stiff blue clay to a depth of 30 ft. from the surface. Water was found in the sand for some distance above the clay but the sand was nearly dry to a depth of 5 ft.

A trench 3 ft. wide and 9 ft. deep was dug, with one face vertical. Into this face horizontal holes were bored for nearly 3 ft., using a ½ in. rod. Electrical resistance thermometers, consisting of a carefully insulated coil of platinum wire about 3 in. long and protected by an external tube of glass or copper, were inserted in these holes and connected to the indicating apparatus by insulated leads of convenient length. The holes were bored at depths of 1, 4, 10, 20, 40, 66 and 108 in. In the earlier periods readings were taken daily at 12 noon, but later a continuous recording apparatus was installed. An abstract of the snow conditions and temperatures recorded will be found in Tables I, II and III.

This record shows very clearly the material effect of snow on the depth of frost penetration and the slight cover probably required when snow is always present early in the winter. The record of the thermometer buried at a depth of 10 in., which showed in April, 1895, a drop of 0.2 to 0.3° below 32°, which was the temperature at the beginning of the thaw, is very interesting. This shows that a lowering of the ground temperature below 32° F. may result from a thaw.

TABLE I.—WINTER 1894-1895.

Depth of thermometer.	Period temperature was below 32° F.	Minimum temperature.	Snow conditions.
Air	Dec. 20 to Mar 20	—10° F. in Feb.	10 in. snow. Dec. 28 which increased to 21 in. by Feb. 1, 33 in. by Feb. 7. Began to melt in March. Final melting of snow between Apr. 7 and 14.
1 in.	Nov. 25 to Apr. 14	27° F. in Dec., just before snow fall.	
4 in.	Nov. 28 to Apr. 14	28° F. in Dec., just before snow fall.	
10 in.	Dec. 16 to Apr. 14	31½° F. in Dec., just before snow fall.	
20 in.	0	33° F. Dec. 14, melting snow.	
40 in.	0	35½° F. Apr. 20, melting snow.	
66 in.	0	38° F. Apr. 21, melting snow.	
108 in.	0	41½° F. Apr. 22 melting snow.	

TABLE II.—WINTER 1895-1896.

Air	Nov. 20 till Apr. 10 except for short rises.	—15° F. Feb. 18.	Practically no snow till Jan. 24. The winter is remarkable for lateness of heavy snow fall and for the rapidity of its disappearance.
1 in.	Dec. 2 to Apr. 20.	27° F. Jan. 22, before snow fell.	
4 in.	Slightly shorter period than for 1 in.	28° F. Jan. 22, before snow fell.	
10 in.	Dec. 22 to Apr. 20.	30° F. Jan. 22, before snow fell.	Light snow fell in Nov. and Dec. disappeared. Heavy snow fall commenced Jan. 24 and increased to maximum of about 30 inches in March. Snow disappeared about April 12.
20 in.	0	32½° F. Jan. 23.	
40 in.	0	34½° F. Apr. 15, melting snow.	
66 in.	0	38° F. Apr. 20, melting snow.	
108 in.	0	41° F. Apr. 25, melting snow.	

The final thawing of the ground took place at a depth of 10 in. on April 19. The 10-in. thermometer, which had remained within less than 0.1° F. for about two months previously, showed a depression of 0.3 when the thaw reached it, probably due to lowering melting point by dissolved salts. . . . The percolation of water caused a slight simultaneous fall in the two thermometers next below.

TABLE III.—WINTER 1896-1897.

Depth of thermometer.	Period temperature was below 32° F.	Minimum temperature.	Snow conditions.
Air	Nov. 15 to Mar. 20	Mean temperature air Dec. 23, 5° F	No snow during early part winter; frost penetrated much deeper into soil than during two years previous; thawing of ground after disappearance of snow was lengthy operation; 20 days were required. Temperature at 20 in. did not rise above freezing till May 1. First fall of snow quite light Dec. 5 Practically no snow till Jan. 20. About 20 in. snow on ground from Jan. 20 to Feb. 20. About Feb. 20 snow increased gradually and uniformly to about 28 in. by Mar. 1. Snow disappears about Apr. 2 or 3.
1 in.	Nov. 23 to Apr. 3	10° F. Jan. 20.	
4 in.	Dec. 1 to Apr. 10	12° F. Jan. 20.	
10 in.	Dec. 15 to Apr. 18	19° F. Jan. 20.	
20 in.	Jan. 5 to Apr. 25	27° F. Jan. 20.	
40 in.	Nearly reaches 32° F. during Mar. and April.	33° F. Mar. and Apr	
66 in.	0	36° F. Apr. 22, melting snow.	
108 in.	0	39° F. May 2, melting snow.	

This record obtained in a carefully conducted experiment is confirmation of the possibility of a thaw causing the freezing of water pipes. The rapid lowering of ground temperature by cold water percolating through the ground was strikingly shown several times during the period covered by the records. While percolating waters may lower the temperature, the presence of moisture reduces the likelihood of services freezing, for the following reasons: (a) The freezing of the water releases latent heat which is transmitted to the ground. (b) The frozen ground is a poor conductor of heat. (c) Water is a poor conductor of heat, and when it is held in the ground by the action of capillarity, it cannot readily conduct heat by convection, as it would if it were free to move.

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THE ECONOMY OF ELECTRICITY FOR OPERATING EXCAVATING MACHINERY.

Electricity has long been used for operating bucket-ladder dredges in California for gold dredging. Within the last ten years there has been a noticeable increase in the rise of electric motors on other types of excavating machinery. For example, a great many dragline excavators are now electrically operated.

In digging 93 miles of ditches and canals near Caldwell, Idaho, the U. S. Reclamation Service has used four Bucyrus dragline excavators equipped with 50-ft. booms and 1¼-yd. buckets. The machines are mounted on caterpillar wheels, and the operating crew is only two men, an operator and an oiler. An 80-hp. electric motor drives the dragline, another 80-hp. motor drives the caterpillar wheels, and a 40-hp. motor operates the swinging machinery.

The ditches have been 5 to 10 ft. wide at grade, with side slopes of 1½ to 1 and 2 to 1. The average cut has been 10 ft. and the yardage has averaged 40,000 cu. yd. per mile. Nearly 3,800,000 cu. yd. have been excavated at a labor and power cost of 5.5 ct. per cu. yd. According to J. L. Burkholder, drainage engineer of the Boise Project, Nampa, Idaho, the cost has been as follows per cubic yard:

	Cts.
Labor	2.3
Electricity	0.9
Supplies	1.1
Electrical lines	1.2
Total	5.5

This does not include interest, depreciation and general expense.

Electricity has cost 1 ct. per kilowatt-hour. The average amount of current used has been 0.88 kilowatt-hour per cubic yard excavated, including all electric line and transformer losses. In light, sandy loam the power consumed has been as low as 0.4 kw.-hr. per cubic yard.

It will be noted that the cost of electricity and electrical lines totals 2.1 ct. per cubic yard, of which the cost of building the electrical lines (transmission lines, telephone lines and substations) was 1.2 ct. per cubic yard. The transmission lines consist of three No. 4 copper wires on 30-ft. poles, carrying current at 4,000 volts, which is transformed to 440 volts. The lines are torn down and rebuilt as the work progresses.

The ditches in this Boise Project averaged 40,000 cu. yd. per mile, from which it may be deduced that the electric lines and substations cost $500 per mile, allowing for the fact that they were rebuilt several times. Had the yardage been, say, twice 40,000 cu. yd. per mile, the 1.2 ct. cost per cubic yard for electric lines would have been cut in two.

In estimating the saving that may be effected by using electricity, two things should not be forgotten:

First, the fuel used in a stationary plant will yield much more steam per ton than the fuel used on a smaller plant mounted on the excavator itself. This arises not only because a more economic type of power plant is ordinarily used for a stationary plant, but because where several different excavators are drawing power from the same stationary plant there is such a diversity in their loads as to give a more uniform load on the stationary plant. This higher "load factor" accounts largely for the economic efficiency of a central power plant, and the greater the number of different motors that it serves the higher the "load factor" or degree of uniformity of power output.

Second, a central stationary plant greatly reduces the number of firemen and enginemen, and it also reduces the cost of transporting coal.

Nearly every electric company has in its employ at least one electrical engineer who is competent to assist an excavating contractor or civil engineer in solving the electrical part of the problem of delivering power economically to excavating machines. Consultation with an electric company's engineer will frequently lead to marked reduction in the cost of excavation.

The editor recalls an instance where an excavating contractor was able to buy at a low price a lot of old telephone poles, badly rotted at the butt but fairly sound above the ground line. He rented the copper wire from the electric company that sold him the "juice," and thus was able to build several miles of transmission line at a low cost. The cost of the transmission line is ordinarily the most expensive item in the application of electricity to excavating earth; but by using small, second-hand poles, and by renting the copper wire and insulators, this item of cost can frequently be so greatly reduced as to permit the use of electricity even where the yardage of earth is relatively small.

Where only a very short transmission line is required, or where none at all is needed, as in cities, there are innumerable chances to use electricity economically on construction work of all kinds. The wonder is that contractors have been so slow in coming to a realization of this fact.

"ONE DAY DANIEL WILLARD PICKED UP A COPY OF WELLINGTON'S BOOK AND—"

During the struggle between the railways and the "big four brotherhoods" last summer, one of the great daily papers printed thumbnail biographies of the gladiators in the political arena at Washington. We were particularly impressed by one incident in the life of Daniel Willard—his reading of Wellington's "Economic Theory of Railroad Location" and the effect of that reading upon his life. We quote:

> There are plenty of life romances among the railroad chiefs. There is Daniel Willard, the much-liked president of the Baltimore and Ohio. Mr. Willard is an art connoisseur, musician and scholar. His collection of portraits of Napoleon is rated as one of the best in the world. Several years ago, while he was conducting a $110,000,000 railroad deal, he took up the study of French. It was years and years ago, up on an old Vermont road, part of the Boston & Maine, that Daniel Willard was a locomotive fireman. One day he picked up a book—Wellington's "Economics of Railroad Location." He bought a copy, tucked it away in his cab, and when he wasn't busy keeping up steam in the boiler to haul his train over the White Mountains he was reading the science of railroading. Then he became a locomotive engineer. He got a job on the Great Northern. Fred D. Underwood, the jovial president of the Erie, was conductor on the train Dan Willard pulled the throttle on. When Underwood became a superintendent he made Willard assistant superintendent. When he became president of the Erie he took Willard along and made him vice-president.

We think it reasonable to say that some one book or article has marked the turning point in the life of the majority of men who have achieved great success. But probably it has not been often that a book written by an engineer for engineers has won the attention of a skilled workman and aroused his ambition, as when Daniel Willard "one day picked up a book and tucked it away in his cab," preliminary to tucking it away in his head.

May each of us not find in this occurrence a lesson? Is there not somewhere a scientific book that we have never read, one that is destined to stir our ambition and rivet our resolution to the accomplishment of something great?

Wellington, it is true, was one author in a thousand. His style was not merely lucid, it was luminous, and he wrote with the enthusiasm of a discoverer. This leads us to remark that many engineers make the mistake of reading only the latest books on a subject. Don't forget that the latest book is often only a dull recital of facts, useful in themselves but not so dressed as to kindle the slightest enthusiasm. Don't read what the Rev. John Bopeep has said about Darwin's theory of evolution, even if he has said it all and more too. Read Darwin's "Origin of Species" itself, for there you will see a great mind at work and enthused with the pleasure of discovery. So, read Wellington in the original. Read him to see with what infinite pains he worked amid a mass of unorganized data, striving to evolve his unifying "economic theory."

The great thinker is a great enthusiast on his subject. Euthusiasm is contagious. The great thinker is necessarily a great logician in his own realm of thought. Logic also is catching. Certainly logic is poorly taught in the textbooks on the subject, so go to the works of the great masters in each line if you would learn their methods of reasoning.

STRIPPING COAL BEDS WITH STEAM SHOVELS.

Elsewhere in this issue we give some interesting cost data relating to stripping earth and rock from beds of anthracite. Practically all of this work is done with steam shovels and a large part is done by contract.

In 1914 about 8,400,000 cu. yd. were stripped in the anthracite region of Pennsylvania, of which approximately 35 per cent was rock. The present costs are about 16 to 20 ct. per cu. yd. for clay and 35 to 40 ct. for rock.

According to Mr. J. B. Warriner, chief engineer of the Lehigh Coal Navigation Co., fully 300,000,000 cu. yd. have been stripped during the past 50 years. The first steam shovel came into the anthracite region in 1881. It was a 30-ton Oswego shovel with a 1-yd. dipper. The sizes of shovels have steadily increased until now 70 and 80-ton shovels are the rule, and largers ones are coming in.

In the early days when wages of laborers were $1.10 for 10 hours, clay stripping cost about 26 ct. per cu. yd., and rock cost 60 ct. Due to the use of larger shovels and other labor-saving devices, the costs are now 30 per cent lower than that, in spite of the fact that wages have almost doubled.

One or two million cubic yard strippings are not unusual, and some of these have been continuously operated for 20 years. The largest stripping operation involves removing 4,500,000 cu. yd. over 53 acres, to a maximum depth of 150 ft.

By stripping the coal a larger yield of coal is obtained and a larger quantity of coal can be removed in a given time. Ordinarily about 3 cu. yd. of stripping per ton of coal may be removed before the limit of profitable open-cut work is reached.

HOW GREATLY IS STEAM SHOVEL OUTPUT REDUCED BY WINTER WEATHER?

This is a question that often becomes very important. In the northern states there are four months—December to March, inclusive—during which all open cut excavation work is conducted under difficulties.

Rarely are any definite figures of cost or output published to show the relation between excavation work during these four months and the rest of the year. In Mr. J. B. Warriner's article, published in this issue, the average output of several steam shovels is given by months over a period of four years. This is the most complete record of its kind that we have seen in print. It will be noted that in this case the average monthly output during December to March, inclusive, was almost exactly three-fourths as great the average monthly output during the remaining eight months.

It should be noted that, for some unexplained reason, the outputs in August and September were below normal for the good working months; but even if they had been up to normal the output for the four winter months would have been 72 per cent of that during the remaining eight months.

Suppose then that a contractor could normally expect to get an output of 20,000 cu. yd. per month per shovel during the eight good months. Then during the four bad months he would have to count on about 20,000 × 72 per cent, or 14,400 cu. yd. per month. If, then, a six-month job were begun the first of September and finished at the end of February, there would be three months at 20,000 cu. yd. and three months at 14,400 cu. yd. or an average of 17,200 cu. yd. per month. On such a job it would be necessary to bid fully 15 per cent higher than if the work were started in April and finished in September.

Experienced contractors are well aware of the higher excavation costs that are incurred in winter months, but we question whether many of them have ever calculated the percentage of increase in cost attributable to Jack Frost.

The figures above given apply only to heavy cut work. Where cuts are shallow and in frozen earth, the winter costs per yard may be more than double those that prevail in warm weather.

WHY INDIANA ENGINEERS SHOULD GET TOGETHER.

"Do you think some of the practicing engineers would be receiving $2 or $3 per day if there were 1,000 engineers [in Indiana] willing to change conditions? Hardly. Look at the disgraceful laws on our statute books defining pay for a competent engineer."

In these ringing words Mr. Chas. Brossmann of Indianapolis, secretary of the Indiana Engineering Society, calls upon the engineers of Indiana to join the society and work together for mutual benefit and for the benefit of the state in which they live.

The next convention of the society takes place Jan. 18 to 20, at Purdue University, Lafayette, and Mr. Brossmann urges engineers in every branch of the profession to attend. He says:

> There are several hundred engineers in the Indiana society—there should be a thousand. With one thousand members the society could make its voice heard; could make the public listen. There is little doubt that it would be heard in the legislature if there were a thousand members to pull together, instead of a mere handful sending resolutions to the legislative committees.
>
> If you do not need it, join the society for the profession's good. Give the other men a boost. Join for the sake of getting acquainted. There are young men who will be prominent some day. You should be glad to know them now. These are bright, companionable fellows whom it is good to come in contact with. Acquaintanceship or friendship may mean a great deal to you some day. Join for the good of the community. It may need you quickly some day. Join for the good of the profession, and, if you are selfish, join for your own good, for if you work at all you will get more out of it than you put in—and join now—don't put it off. The amount of dues should not stand in the way; and if you feel you are not getting what you should from the profession, the quicker you join and get others to join the better for you.

We need hardly say that we are in hearty accord with this utterance. The program of addresses and papers indicates that the convention will be well worth while from a technical point of view. But it will be even more worth while because of the greater unity of purpose that it will bring about. Yes, a thousand engineers pulling together can accomplish a vast deal, and certainly no mean task confronts Indiana engineers if they would raise the compensation of engineers in public service.

EDITORIAL COMMENT.

Pulverized coal as a fuel for steam boilers is relatively new, but for cement and other kilns it has been used for years, the consumption now being 8,000,000 tons a year. Coal is ground to the fineness of Portland cement at a cost of about 25 ct. a ton. In a paper on "Pulverized Fuel for Locomotives," recently read by Mr. John E. Muhlfeld before the American Society of Mechanical Engineers, it is estimated that about one-quarter of the fuel burned by locomotives is expended while the locomotive is standing still. Most of this present loss of fuel can be eliminated by burning powdered coal. He also states that the steaming capacity of a boiler can be doubled.

Flexible metal hose for steam drills lasts fully three times as long as rubber hose, according to a statement in Gillette's "Handbook of Rock Excavation." Can any of our readers give further definite information on this subject?

Muddy earth when dumped into a bin will often arch in such a manner that it will not run out into a wagon or car. Some years ago we published the fact that a contractor had overcome this difficulty by using a steam jet to loosen the muddy earth and make it run out. A 1-in. gas pipe 8 ft. long was attached to a hose from a steam pipe. The gas pipe was forced down into the earth in the bin until its nozzle was just above the gate through which the earth was drawn off. By turning on the steam for a few moments the muddy earth was made to flow out the gate.

Freshly mixed concrete is occasionally stored in a small bin for a few minutes before it is drawn off and placed in the forms. If it is not very wet it will not flow readily from the bin. In such cases use a steam or air jet as described in the previous paragraph and the trouble will vanish.

RENTAL RATE FOR CONTRACTOR'S EQUIPMENT.

To the Editor: I notice in your issue of Nov. 22 an editorial entitled, "Guaranteed Cost Plus a Percentage Contract." I have believed for some time that this would be a good line to work along with the real estate men in this city.

As the price of labor and material has increased so suddenly all contractors are bidding high to protect themselves. In many cases I believe the real estate companies would be willing to share the risk with a contractor, who has a reputation for doing things, in the hope of keeping down the cost. I would be pleased to receive any information you may have on this plan regarding equipment, upkeep of same, charge for its use and how made and the usual per cent charged. Is a charge made on material also, in case any is used?

Any information you may have will be gratefully received.

Toledo, O. S. L. Cothrel.

[Equipment usually is rented at a monthly price. The following figures are those quoted by a western contractor:

	Monthly rental.
Gasoline or steam roller (10 ton)	$150
Concrete mixer	100
Elevating grader	125
Road grader	50
Gang plow	20
Ordinary heavy plow	[illegible]
Oil or water wagon	25
Rack wagon	10
Dump wagon	[illegible]
Wheeled scraper	[illegible]
Fresno scraper	[illegible]
Large blacksmith outfit	100
Kitchen outfit	30

Current small repairs are made at the expense of the user, but heavy overhauling is done at the expense of the contractor. The contractor customarily receives 10 per cent on the labor and material he provides, and for supervision. We shall be glad to receive information from our readers regarding rental rates on building equipment.—Editor.]

ENGINEERS FOR COUNTY MANAGERS.

To the Editor: I read with pleasure your editorial in the issue of Nov. 29 regarding engineers for county managers and heartily am in favor of same.

It is a difficult task, though, to convince the rural voter that any change is necessary and such a plan even with an able business engineer open for the office is hard to put over owing to the status of the engineering and surveying profession among such communities.

Why just try to educate the public to city and county managers when all our great states and the Federal Government with their "pork" business and ballahooing could be handled with wonderful economic saving to all generations by a "general manager of Wyoming, United States," etc. Let's go the limit.

Clearmont, Wyo. C. F. Place.

To the Editor: We have been very much interested in the editorial of your issue of Nov. 29 regarding engineers for county managers and wish to be placed on the roll of those who are very much in favor of such an organization.

We can see no reason why "county management" should not meet with popular approval once it is inaugurated, and especially where any considerable amount of road and bridge improvement is going on.

If such an organization can be formed, it is our opinion that the entrance requirements should be high so that none but competent men in that line of work can enter, thus making the title and name of belonging worth striving hard for.

However, we of Texas have a long ways to go yet in the way of educating the people up to that point, as we can not even boast of a State Highway Department. However, we hope to be able to get a bill passed establishing such a department during the meeting of the present state legislature.

Bryant & Hoffman,
Civil Engineers.
Hereford, Tex.

PATENTS ON REINFORCED CONCRETE STRUCTURES.

To the Editor: In your issue of Dec. 27, 1916, on page 564, you published a short article entitled, "Two of the Luten Patents on Reinforced Concrete Declared Invalid." Your readers may gain the impression from this publication at this late date that the decision referred to is a recent one. But as a matter of fact Judge Sater rendered his oral opinion in October, 1915, over a year ago and his written opinion in August, 1916. This decision was in the lower court and is now pending appeal.

You conclude your article with the statement:

> Securing patents on improvements in the design of engineering structures is relatively easy, but defending them successfully against attack has become exceedingly difficult.

I question whether this statement truly represents the situation in the reinforced concrete building art at the present time. Up to the present seven patents on reinforced concrete structures have been sustained and declared valid by the Circuit Court of Appeals of the United States. They are Hennebique, Ransome, Thacher, Bone, Ferguson, Norcross and Nolte. But one such patent has been held invalid, the Turner patent.

It is true that there have recently been several decisions in the lower courts adverse to such patents, but all of them with possibly one exception have been appealed and are now pending appeal.

Daniel B. Luten,
Designing and Consulting Engineer.
Indianapolis, Ind.

Drilling Performance With a Jackhamer.—The Ingersoll-Rand Co. reports what may be a world's record for drilling of its kind. At the quarry of the Alabama Marble Co. one of the Jackhamer operators put down 100 4-ft. holes in marble in 10 hours. This is drilling at the rate of 8 in. each minute of the day's work. The holes are nearly vertical, only a few inches apart, and are used for plug and feather work.

FACTORS CONTROLLING MAXIMUM OVERALL DIMENSIONS OF MOTOR TRUCKS.

Motor truck designers are being constantly confronted by engineering and contracting problems that would require motor trucks of capacities greater than at present existent and practical. The designer finds few things in the nature of pure automobile engineering problems that would prevent him increasing the size of trucks. There are, however, physical and legal restricting factors that control and restrict the maximum overall dimensions of motor trucks and prevent attainment of the higher efficiency that can be expected to result from an increase of vehicle size. In a paper presented in December before the Section D of the American Society for the Advancement of Science Mr. A. F. Masury, chief engineer, and George O. Hanshew, of the engineering department of the International Motor Co., outline the factors controlling maximum overall dimensions of trucks. The paper, practically in full, follows:

Existing Physical Factors.

Overall Height.—The overall height of present motor trucks seldom exceeds 12 ft. The height is limited by the headroom necessary to drive under such structures as railroad bridges (grade crossings), enclosed or top bridges, elevated railroad structures, overhead trolley wires, doorways of buildings, ferry boats.

Railroad grade crossings seldom provide less than 12 ft. headroom. Enclosed top bridges do not always provide as much as 14 ft. clearance. The doorways of modern garages, built to accommodate present motor trucks, are made with 12 ft. 3 in. headroom. However, few garage doors exceed 10 ft. in height.

Overall Width.—The overall widths of present motor trucks are in very few instances in excess of 96 in. This dimension is limited by the distance between parts of such structures through which vehicles must be driven, as doorways, elevators in buildings, ferry boats.

Doorways of modern garages, built to accommodate present-day motor trucks, are made with a clearance between the butts of at least 10 ft. 9 in., which allows sufficient space for the fastenings of the doors without interfering with vehicles as they pass in or out. Elevators in modern truck garages are made 11 ft. wide.

Overall widths are to a great extent controlled by conditions that minimize the clearances between passing vehicles and the clearances between passing vehicles and stationary objects, as posts, trees, poles, elevated railroad pillars, curbs, etc., and that make negotiation both difficult and dangerous.

Many state roads are paved over a width of but 16 ft. Country roads are usually narrower than this. The difficulties of operating in congested city traffic tend also to restrict widths. Small vehicles are more easily handled.

The following tabulation shows the maximum width and height of motor vehicles allowed on the ferries going into the state of New Jersey:

STATEN ISLAND TRANSIT RAILWAY CO.

	Overhead Clearance.	Width.
Ferryboat Tottenville	12′ 4″	7′ 5″
Ferryboat Perth Amboy	12′ 6″	7′ 7″

PUBLIC SERVICE RAILWAY CO. BERGEN POINT.

Boat.	Height.	Width.	Width Between Wheel Guards.
Bayonne	11.7	10.	7.9
Public Service	15.5	8.2	6.6
Public Service	15.5	9.9	9.1
EDGEWATER.			
Englewood	10.9	9.1	7.1
Leonia	12.8	9.3	7.3
Edgewater	10.9	9.6	8.0
Port Lee	12.2	9.9	7.7

CARTERET FERRY CO.

Overhead clearance of boats	13′
Clearance of passageways	9′ 6″
Passageway between combings	7′ 6″

	Height.	Width.
Penna. R. R.	12′ 4″	10′
D. L. & W. R. R.	12′ 2″	9′ 6″
Erie R. R.	12′ 6″	10′ 6″
Central R. R.	12′ 6″	10′ 0″
West Shore R. R.	12′ 0″	8′ 0″
Penna. R. R. at Camden		8′ 6″
Penna. & Reading R. R.		8′ 6″

Overall Lengths.—The material to be transported is the most important factor controlling length. Overall lengths of existing motor trucks seldom exceed 24 ft. Overall lengths of tractors and semi-trailers seldom exceed 35 ft. Ladder wagons for fire department use sometimes attain lengths of 40 to 45 ft. Structural steel girders, telegraph poles, timbers and similar materials sometimes in excess of 60 ft. are transported by tractors and semi-trailers. Tractor and trailer trains have attained lengths of over 80 ft., but are difficult to handle because the trailers "cut under" on turns.

Lengths are also controlled and restricted by the difficulties encountered in negotiating turns, particularly where roads are narrow and cross at acute angles, and stationary objects, as posts, poles, pillars, trees, etc., are located in close proximity to the sides of the roads.

It is, of course, obvious that wheelbase length is the most important factor that determines the turning radius of motor vehicles, and that the radius increases as the length increases.

TABLE I.—MOST IMPORTANT AVERAGE DIMENSIONS OF TRUCKS.

Type.	Capacity.	Wheelbase	Extreme length.	Length, back of cab.	Extreme width. Ins.	Heighth of loading platform. Empty. Ins.	Height of loading platform. Loaded. Ins.	Clearance. Ins.
Type 1	1-ton	12′	16′	9′ 2″	68	36	32	9½
	2-ton	13′	17′	9′ 2″	68	38	34	9½
	3-ton	13′ 6″	20′ 6″	11′ 0″ to 11′ 6″	87	42	38	10
	4-ton	14′ 6″	21′ 6″	12′ 0″ to 12′ 6″	87	42	38	10
	5-ton	15′ 6″	22′ 6″	13′ 0″ to 13′ 6″	87	44	38	10
	7½-ton	16′ 6″	23′ 6″	14′ 0″ to 14′ 6″	87	44	38	10
Type 2	3-ton	11′ 6″	18′ 3″	12′ 6″	87	42	38	10
	4-ton	12′ 6″	30′ 3″	14′ 6″	87	42	38	10
	5-ton	13′ 6″	22′ 3″	16′ 6″	87	14	38	10
	7½-ton	14′	23′ 3″	17′ 6″	87	44	38	10
Type 3	5-ton	11′ 10½″	18′ 1″	14′	93½	46	40	7½
	7-ton	13′ 4½″	20′ 1″	16′	93½	46	40	7½
	10-ton	14′ 2½″	22′ 1″	18′	93½	46	40	7½
Power-dump	5-ton	11′ 9″	16′ 5″	8′ 3″	87	44	39	10½
Truck, Type 1	7½-ton	12′ 10″	17′ 5″	9′ 3″	87	44	39	10½

TABLE II.—TURNING CIRCLES.

Type.	Capacity.	Wheel-base	Diameter of Turning Circle. Ft.	Type.	Capacity.	Wheel-base.	Diameter of Turning Circle. Ft.
Type 1	1-ton	10′ 6″	47	Type 1	4-ton	12′ 6″	55
		11′ 6″	53			13′ 6″	59
		12′ 6″	55			14′ 5″	61
Type 1	1½-ton	10′ 6″	47	Type 1	5-ton	12′ 6″	57
		11′ 6″	53			13′ 6″	62
		12′ 6″	55			14′ 6″	68
		13′ 6″	60	Type 1	7½-ton	12′ 6″	57
Type 1	2-ton	10′ 6″	47			13′ 6″	62
		11′ 6″	53			14′ 6″	68
		12′ 6″	55			15′ 6″	71
		13′ 6″	60	Type 2	3-ton	11′	47
Type 1	3-ton	12′ 6″	55			11′ 6″	49
		13′ 6″	59			12′	51
		14′ 6″	61	Type 2	5-ton	11′ 6″	53
				Tractor	3-ton	10′ 4″	40
				Tractor	5-ton	10′ 8″	41

The trailer will usually cut under.

TABLE III.—IMPORTANT DIMENSIONS AND TURNING RADII OF TYPE 1, TRUCKS AND TRACTORS.

Tons Capacity.	Wheelbase. Ins.	Width		Heighth to Top of Cab. Loaded.		Length.	Turning Radius. Ft.	Length Back of Cab. Ins.
		Chain Drive.	Worm Drive.	Chain Drive.	Worm Drive.			
1	132	73¾	72¾	93¼	93⅝	205	22	108
1	144	73¾	72¾	93¼	93 11/16	217	25	120
1½	144	73¾	73¼	93 13/16	94⅜	217	25	120
1½	162	73¾	73¼	93 13/16	94⅜	241	29	144
2	144	73¾	73¼	94	94⅛	217	25	120
2	162	73¾	73¼	94	94⅛	241	29	144
3½-Tractor	119	84⅜		98¼		180¾	*21	87
3½	156	84⅜		98 3/16		225¾	25	132
3½	168	84⅜		98⅛		249¾	26′ 3″	156
3½	180	84⅜		98 1/16		273¾	26′ 6″	180
5½-Tractor	119	90⅝		98⅜		180¾	*21	87
5½	156	90⅝		98 5/16		225¾	25	132
5½	168	90⅝		98¼		249¾	26′ 3″	156
5½	180	90⅝		98 3/16		273¾	26′ 6″	180
7½-Tractor	119	93		98⅝		180¾	*21	87
7½	156	93		98½		225¾	25	132
7½	168	93		98⅜		249¾	26′ 3″	156
7½	180	93		98¼		273¾	26′ 6″	180

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*The trailer will usually cut under.

Existing structures tend to restrict length by making negotiation difficult. Modern truck garages, built to accommodate present vehicles, require posts which are spaced at least 16 ft. 6 in. from the walls and 22 ft. apart. This allows three trucks to be backed in between the posts and allows the front wheels of most trucks to project beyond the posts. Aisles about 25 ft. wide provide turning space, which is usually sufficient for the trucks to be driven out from their positions. When a large number of trucks are stored the difference in the sizes of small and large trucks allows this arrangement to be worked out with economy of space. These dimensions can be properly considered as of maximum average. Elevators of modern truck garages are made 24 ft. long. Platform scales for weighing modern motor trucks are built to accommodate vehicles having a wheelbase length of 16 ft.

Trucks may be divided into three classes, according to the arrangement of the engine and the driver's seat:

Type 1.—This is the usual touring car type. The engine is over the front axle; the driver and control are behind the engine.

Type 2.—In this type the engine is over the front axle; the driver and control are directly above the engine.

Type 3.—The engine is over the front axle; the driver and control are on one side of the engine, and the helper is on the other side.

Types 2 and 3 conserve the length of the chassis, as less space is taken for the driver's seat and control, thus allowing a longer loading platform in proportion to the wheel base than type 1.

The position of the operator's seat, whether back of or over the engine, usually affects the dimension of length to a greater extent than the height. When the seat is placed back of the motor, about 40 in. more frame length is required.

Tables I, II and III list motor truck data and show the most important, and what can be properly considered as average, dimensions of motor trucks as they are at present met with in practice.

Vehicles of maximum dimensions as follows have been either projected, designed or built, and are in few instances extreme, the figures serve to show simply a few conditions: 5½-ton tractor-trailer for transportation of milk; width, 90⅝ in.; height, 11 ft.; length, 321¼ in. Truck equipped with body to carry timbers 85 ft. long. 6½-ton, 180½-in. wheel base truck, designed with racks to carry steel; width, 96 in. 2-ton, 10-ft. wheelbase truck, designed with special semi-trailer of 20-ft. wheel base, to transport aeroplane 30 ft. long. 7½-ton tractor, designed with special semi-trailer, which carries a foam tank of 15 tons capacity; height, 10 ft. 6 in.; length, 26 ft. 9 in.

Legal Factors.

A few of the restrictions imposed by legislation will suffice to show that the maximum dimensions allowed are in some instances even less than those of many present motor trucks, and in other instances are but slightly larger, and it appears that average motor trucks considered as a whole are rapidly approaching their legal limits.

The legal restrictions cited, while they are few in number, are fairly representative of the average legal maximums that would be determined by a more exhaustive study.

TABLE IV.—FACTORS IN THE COST OF OPERATION OF MOTOR TRUCKS.

Tons, capacity.	Average cost of chassis.	Miles per hour.	Driver's salary, per year.	Garage, per month.	Miles per day.	Maintenance, per year.	Gasoline, per year.	Oil and grease, per year.	Tires, per year.	Interest, per life.	Insurance, per life.	Depreciation during life.	Cost, per year.	Miles of life at each mileage per year.	Life of truck, in years.	Cost, per life.	Cost, per day.	Tire cost per mile.	Gasoline cost per mile.	Miles of use, per year.
			$780		40	$120	$300	$120	$360	$408	$260	$1,626	$2,197	100,000	8.3	$18,241	$7.33	$0.03	$0.025	12,000
1	$1,963	19	830	20	60	240	450	190	540	231	147	833	3,106	85,000	4.7	14,601	10.36	0.03	0.025	18,000
	(12)		900		90	360	675	270	810	117	75	426	3,531	65,000	2.4	8,476	11.77	0.03	0.025	27,000
			780		25	135	276	102	341	533	331	2,140	2,199	100,000	9.6	21,117	7.33	0.0325	0.0262	10,500
1½	2,225	18	830	21	50	270	395	150	488	317	202	1,270	2,698	85,000	5.7	15,922	9.00	0.0325	0.0263	15,000
	(12)		900		90	405	710	270	878	133	85	535	3,728	65,000	2.4	8,948	12.43	0.0325	0.0262	27,000
			780		35	150	288	75	393	663	461	2,660	2,361	95,000	9.1	21,489	7.87	0.0375	0.0274	10,500
2	2,918	17	830	22	50	300	415	150	563	408	283	1,818	3,067	85,000	5.6	17,177	10.22	0.0375	0.0276	15,000
	(8)		900		80	450	660	225	900	246	136	789	4,026	65,000	2.7	10,877	13.42	0.0375	0.0275	24,000
			780		30	180	292	75	.404	893	572	3,575	2,233	90,000	10.0	22,333	7.44	0.045	0.0324	9,000
3	575	15	830	23	50	360	487	150	678	473	303	1,989	3,612	80,000	5.3	19,145	12.04	0.045	0.0324	15,000
	(6)		900		80	540	781	225	1,081	241	154	1,018	4,329	65,000	2.7	11,716	14.43	0.045	0.0324	24,000
			780		30	240	360	75	450	1,016	650	4,066	2,761	90,000	10.0	27,613	9.20	0.05	0.04	9,000
4	4,066	14	830	24	50	480	600	150	750	538	344	2,140	3,666	80,000	5.3	19,431	12.22	0.05	0.04	15,000
	(3)		900		70	720	840	225	1,025	364	195	1,210	4,566	65,000	3.0	13,698	15.22	0.05	0.04	21,000
			800		30	240	406	90	540	1,125	720	4,500	2,920	90,000	10.0	29,205	9.74	0.06	0.045	9,000
5	4,500	12	900	25	50	480	678	180	900	526	311	2,380	4,072	80,000	5.3	21,184	13.58	0.06	0.045	15,000
	(10)		1,000		70	720	948	262	1,260	337	216	1,350	5,124	65,000	3.0	15,373	17.08	0.06	0.045	21,000
7½	5,400	9	800	26	25	255	395	94	750	1,525	976	5,400	3,367	85,000	11.3	38,051	11.22	0.10	0.0526	7,500
	(2)		900		40	510	630	150	1,200	837	535	2,348	4,463	75,000	6.2	27,673	14.88	0.10	0.0525	12,000
10	5,500	7	800	28	25	270	468	94	1,200	1,553	994	5,500	3,943	85,000	11.3	44,561	13.15	0.16	0.0624	7,500
	(1)		900		40	540	750	150	1,920	852	545	3,410	5,371	75,000	6.2	33,303	17.90	0.16	0.0625	12,000

TABLE V.—OPERATING COSTS.

Tons capacity.	Cost of chassis with standard equipment.	Cost of body.	Total investment.	Interest on half total investment @ 6%.	Fire insurance @ 2% on 80% of total investment.	Fixed depreciation exclusive of tires @ 10%.	Maintenance per mile.	Maintenance per year.	Tires per mile.	Tires per annum.	Gasoline per mile.	Gasoline per annum.	Oil per mile.	Oil per annum.	Total cost per annum.	Total cost per day.	Total cost per ton mile.
1	$2,150	$200	$2,350	$ 70.50	$37.60	$216.00	$0.015	$135	$0.026	$234.00	$0.0313	$281.70	$0.006	$ 54.00	$2,308.80	$ 7.70	$0.246
2	2,800	225	3,025	90.75	48.40	281.65	.02	180	.03	270.00	.0357	321.30	.008	72.00	2,544.10	8.48	.131
3*	3,400	250	3,650	109.50	58.40	342.00	.03	270	.045	405.00	.050	450.00	.02	180.00	3,094.90	10.32	.115
3½.....	3,650	250	3,900	117.00	62.40	361.56	.03	270	.045	405.00	.050	450.00	.015	135.00	3,080.96	10.27	.0978
5*	4,000	300	4,300	129.00	68.80	404.00	.04	360	.055	495.00	.071	639.00	.025	225.00	3,600.80	12.00	.08
5	4,800	300	5,100	153.00	81.60	481.50	.04	360	.045	405.00	.050	450.00	.015	135.00	3,346.10	11.15	.0743
5½.....	4,250	300	4,550	136.50	72.80	422.99	.04	360	.0525	472.50	.054	486.00	.02	180.00	3,410.79	11.36	.069
6½.....	5,800	300	6,100	183.00	97.60	577.00	.04	360	.05	450.00	.054	486.00	.015	135.00	3,568.60	11.90	.061
7½*....	4,500	300	4,800	144.00	76.80	445.00	.045	405	.07	630.00	.080	720.00	.03	270.00	3,970.80	13.23	.059
7½.....	4,600	300	4,900	147.00	78.40	451.84	.045	405	.0625	562.50	.062	558.00	.025	225.00	3,707.74	12.36	.055

*Old Model.

The above table has been computed on the basis of:

300 working days per year
30 miles per day.
9,000 miles per year.
100,000 miles, life of truck.
25 ct. per gallon gasoline.
60 ct. per gallon lubricating oil.
$20 per week wages.
$20 per month garage.

A few legislative regulations restricting dimensions:

Chicago ordinance, passed May 17, 1915, under subject "Tractors and Trailers: Regulations for Speed, Size and Capacity." Section 6 limits as follows:

Maximum overall length of truck and trailer, 40 ft.

Maximum overall width of truck and trailer, 102 in.

Section 7. Permits issued to operate train of trailers up to 100 ft. long between 8 p. m. and 5 a. m. at 8 miles per hour.

Laws of Pennsylvania: Ninety in. maximum width over vehicle and load. Buses in cities of first, second and third class and tractor engines may be 100 ins.

Laws of Maryland: Ninety in. maximum width allowed. Tractor engine may be 100 in.

The 1904 motor car order (England) limits the width of heavy motor cars or trailers to 7 ft. 6 in.

Vehicles for military service in England are limited as follows: Maximum width, 90 in. for 3-ton trucks; 90 in. for trailers.

Ton-Mile Efficiency.

High ton-mile efficiency leads to big units, which is shown by a comparison of the cost of operation of trucks of different capacities and is evidenced by Tables IV and V.

Future.

From the foregoing it will be seen that the present physical conditions restricting the overall dimensions have largely been the controlling factors in establishing the legal restrictions.

The present tendency in design is toward still larger units, and is the result of the increase in ton-mile efficiency that is possible only with large units.

We can reasonably expect physical changes in the future that will take place slowly and naturally and that will surely lead to conditions that will permit motor trucks to be increased in size far beyond the present legal maximum limits.

The amount of capital invested in the motor truck and its allied industries cannot be accurately ascertained and estimated. Figures are not available. However, it is obvious that it represents a proportion of the total money invested in the automobile and allied industries that is by no means small.

The National Automobile Chamber of Commerce estimates the number of commercial motor vehicles in the United States at 250,000, and the average cost of 1915 vehicles at $2,000 each; 1916 vehicles at $1,800 each. The annual expenditures on the construction and maintenance of highways in the United States is $250,000,000. There are 2,121 automobile engineers in the Society of Automobile Engineers alone.

In face of these facts it does not seem unreasonable to expect that the inertia of money and the enlistment of engineering talent of the highest order in the industry will unite to accelerate change, and to overcome the present physical restrictions and the legal restrictions that together prevent the attainment of the maximum efficiency that it is possible for engineers to produce.

Some Drilling Performances in Igneous Mica Rock.

Some interesting tests of Hummer drills were made recently in the igneous mica rock which is being excavated at the corner of East 149th St. and Eagle Ave. in the Bronx, New York City. The results, as reported by the manufacturers of the drills, Chicago Pneumatic Tool Co., are as follows: The first test was made with a Type A 66 Little Hummer, using ⅞-in. hexagonal hollow steel, collared drill, with the following results:

20-in. hole in 2 minutes 7 seconds; starter, 1¾ in.
16-in. hole in 1 minute 20 seconds; second drill, 1⅝ in.
Total 36-in. hole, 3 minutes 27 seconds.

The second test was made with a Type C 66 Big Hummer, using 1⅛-in. hexagon hollow steel, collarless drill, with the following results:

	Length of Drill.	Kind of Bit.	Depth Drilled.	Time Occupied.
Starter	2'6"	*2¼"	24"	2 minutes 10 seconds
Second	5'6"	†2"	26"	3 minutes 15 seconds
Third	[illegible]	†1⅞"	34"	2 minutes 10 seconds
Fourth	10'	†1¾"	36"	4 minutes
Total			120"	11 minutes 35 seconds

*Rose. †Cross.

CONSTRUCTION OF A NARROW GAGE RAILWAY IN THE REPUBLIC OF PANAMA.

On May 1, 1916, the first trains were operated over the Chiriqui Ry. in the Republic of Panama. This railway is a 3-ft. gage line and is located 200 miles west of the Panama Canal. It extends from Pedegal on the Pacific Coast to David, the capital of Chiriqui Province, into branch lines to La Concepcion, Potrerillos and Boquete. The construction of the railway was described by Mr. A. S. Zinn, the Consulting Engineer, in a paper presented before the Western Society of Engineers. Mr. Zinn's paper is printed in the November Journal of the Society from which the following is taken:

In February, 1914, the contract was let to W. R. Hebard & Co., of New York City and Panama, for the engineering and complete construction and equipment of the railway, ready to operate; all plans, pay rolls, equipment, construction, etc., to be approved by the Consulting Engineer.

As the Government had very little money in its treasury, the President was authorized to negotiate a bond issue abroad to such an amount as would be necessary to complete the railroad. The approval of the State Department at Washington was secured and negotiations were eventually concluded for the sale of the 30-year 5 per cent Republic of Panama bonds at a good price.

The construction work was started in April, 1914, and carried on slowly for seven months at the entire expense of the contractors on account of the delay in financing the project, the Government not being able to secure any money on the bond transaction until November, 1914. The work was then continued with a much larger force of men and the best available construction equipment, consisting of two second-hand 18-ton saddle tank type locomotives from the Panama Canal, two new 87-ton consolidation type locomotives, one pile driver, one 70-ton steam shovel, one wrecking crane, 12 dump cars, 20 flat cars, 75 one-yd. hand dump cars with 8,000 ft. of 2-ft. gage track, six section cars, three motor cars, etc. All construction equipment was to belong to the Government on completion of the work according to contract. Most of the excavation, amounting to 410,223 cu. yd., was done by hand with the use of the 1-yd. steel dump cars pushed by hand on 2-ft. gage tracks that could be quickly laid and shifted to any position required. This method of handling material from narrow cuts and short haul fills was found to be an economical method in handling a large quantity of material in connection with the Panama Canal work and is popular with all contractors doing work in the tropics where they have to contend with a great deal of rain and mud, native and Jamaican laborers being employed at a certain price per car. Grading with teams and scrapers is very seldom done, as it has proved to be slow and expensive. The steam shovel was only used to load the gravel for ballast. The total length of main lines exclusive of side tracks is 57 miles. On the line to La Concepcion, a distance of 18 miles, the maximum grade is 3 per cent and the maximum curvature 6 degrees. On the line to Boquete of 32 miles the maximum grade is 5 per cent and the maximum curvature 12 degrees.

In climbing the slopes leading up to the mountains around Boquete for a distance of nine miles the average grade is 4.2 per cent and the maximum curvature 5 degrees. On the Potrerillos 7-mile spur track the maximum grade is 5 per cent and the maximum curvature 5 degrees.

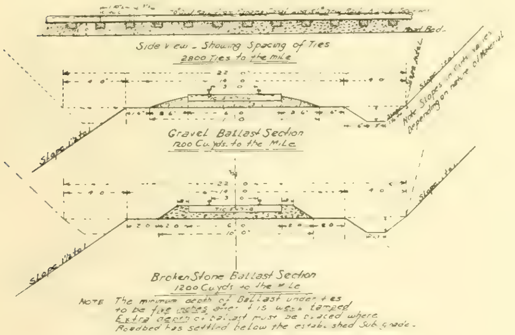
The consolidation type engines purchased were guaranteed to haul 120 tons behind the tender, up a 5½ per cent grade, at a speed of 10 miles per hour. It was found by actual test that one of these engines hauled 150 tons at a speed of 15 miles per hour, up a 5 per cent grade, part of which grade was on a 12 degree curve. The specifications for the formation of the roadway were practically the same as recommended by the American Railway Engineering Association.

The principal things to be provided for in the construction of a railroad in the tropics are good side ditches and sufficient openings with well constructed culverts and bridges. The rainy season continues for eight months each year, during which time in Chiriqui the rainfall averages about 140 in. or about 3½ times the total precipitation in Illinois for one year.

To provide for the safety of the 57 miles of track, in such floods, it was found necessary to construct 26 steel bridges and 108 culverts. The majority of the culverts were made of corrugated iron pipe, 24 in. to 72 in. in diameter, with concrete end and wing walls. All the large pipes under heavy fills were reinforced throughout with one foot thickness of concrete to prevent sagging. The balance of the culverts, 6 ft. by 6 ft. to 10 ft. by 10 ft., were made of reinforced concrete and rubble stone masonry. The American Railway Engineering Association's general specifications for steel railway bridges and coopers E. 30 for minimum loading were adopted. All of the steel bridges were furnished by the American Bridge Co.

The bridge material was shipped from New York to Colon, about two thousand miles, and was loaded on Panama Railroad cars and taken across the Isthmus. The larger parts were unloaded on U. S. docks at Pacific entrance to Panama Canal, and reloaded on ocean going barge. The smaller parts were unloaded on docks at Panama, reloaded on small barges and taken out about a mile and transferred to a larger boat which was built for hauling cattle and passengers, with no modern equipment for loading and unloading construction material. The material was then taken up the Pacific coast 325 miles and unloaded at the new dock at Pedregal, to be hauled by work train to bridge sites.

The masonry for the bridges was built in advance of track work, and consequently it was necessary to haul the cement and form lumber in ox carts for 5 to 20 miles over very bad roads.

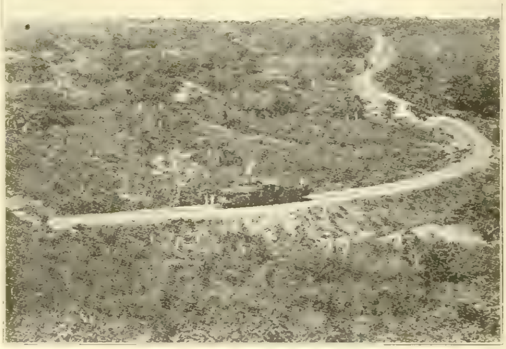

Road Bed
Side View – Showing Spacing of Ties
2800 Ties to the mile
22' 0"
14' 0"
Gravel Ballast Section
1200 Cu. yds. to the Mile
Slope 1½ to 1
Note Slopes in Cuts varies Depending on nature of Material
Broken Stone Ballast Section
1200 Cu. yds to the Mile
NOTE The minimum depth of Ballast under ties to be five inches after it is well tamped
Extra depth of ballast must be placed where Roadbed has settled below the established Sub grade.

Standard Roadbed and Ballast Section.

The rock for the concrete was crushed by hand at the bridge sites and all concrete was mixed by hand and wheeled into the forms. This method was cheaper than using a concrete mixer.

As soon as the track was laid to a bridge site, the heavy false work timbers for erection, made from native Mangley timber, were delivered by work train, with but one exception, and as soon as erected the steel work was delivered and erected with very little delay. The culvert pipe was all hauled by ox teams and put in place ahead of the grading. All of the concrete work for the culverts was completed after track was laid, to save money in transportation of material.

As soon as the track was laid on the sub-grade for about 15 miles the ballasting with broken stone was started. As plenty of stone of good quality was found all along the line between David and Boquete, the use of a portable crusher was suggested to the contractor. He was in favor of a stationary crusher. Finally a young foreman said he believed he could use native labor to break by hand the boulders along each side of the roadbed and rock from the rock cuts and do it cheaper and more satisfactorily than could be done with either a portable or stationary crusher. For experiment he was allowed to break stone for one mile of ballast and it was found he was correct. Consequently all of the broken stone ballast over 33 miles of the road was broken by hand, the big saving being in the fact that it was piled up all along the roadbed in long piles, one foot high by three feet wide, for convenience in estimating, which also saved transportation expenses, as it could be thrown in place with shovels. In the original estimate, creosoted ties 5 in. by 7 in. by 6 ft. were specified. These would have to come from the United States and about 168,000 would be required. After the contractors had delivered about 40,000 creosoted ties, the Consulting Engineer recommended to the Government that native ties of the best available woods be used. About fifteen varieties of wood were specified, the better quality being Lignum Vitae, Mameycilla, Mora, Moria and Corotu.



Line Crossing Rio David Valley, Maximum Grades, 5 per cent; Maximum Curvature. 12°.

The principal reasons for recommending native ties were that the money expended for them would benefit the people in the province and after four or five years they would know from experience the best kind of wood to use in tie renewals for maintenance and would not be required to wait for shipments from the United States.

While some very good native ties were furnished, yet, as a whole they were not as good as the creosoted ties, and on account of the scarcity of timber and the inexperience of the men furnishing the ties it not only delayed the work but proved to be more expensive than to have shipped creosoted ties from the United States.

Line Entering Boquette Valley at Elevation of 3,500 ft. Above Sea Level.

It was decided at first to use all 75-lb. second-hand rail from the Panama Canal, but after receiving enough for 26 miles of track no more could be had that was good enough for the purpose; so the balance of the track was laid with new 56-pound rails—both being A. S. C. E. sections.

The right of way fences were built in the same manner as is customary by the natives, by stretching four barbed wires on wild plum posts. Large posts were firmly set in the ground about every 30 ft. to stand the pull on the wire, and in between about every 2 to 3 ft. small plum posts, 2 in. to 3 in. in diameter, were set about 1 ft. in the ground. These soon take root and grow rapidly, so that in a few years the posts are a line of growing trees, which make a very good fence, with small cost for maintenance. However, on account of the delay in securing the great number of posts required, and the time it takes to build such a fence, Mr. Zinn stated that he would hereafter recommend for a similar country all indestructible fence posts with five barbed wires.

Most of the cattle guards were steel surface guards with the side fences and posts made by sawing up the sheet piling used at the bridge foundations. This would not be economical in this country, but down there, where we had no more use for the piling and the cost of transportation is high, it was economical. It cost very little to saw them and drill holes at the shops ready to deliver and erect at the road crossings.

No reverse curves were allowed. The only curves where spirals were used were at places where trains are likely to run at a speed of over 20 miles per hour. On account of the steep grades the trains will not be required to run at an average speed of over 18 miles per hour; consequently the superelevations of outer rails on curves were made to correspond.

During the construction period, wood was first used in the engines and then coal. The necessary number of oil tanks was being erected so as to be able to change the engines to oil burners soon after the road started operation, as it was proven on the Panama Canal and Panama Railroad that it was cheaper to use oil.

The original form of contract adopted was that known as "cost, plus a percentage, with a bonus for economy." Soon after the work started the Consulting Engineer saw the trouble and extra expense it would cause the contractors and the Government to carry out such a contract 325 miles from headquarters. Under the "cost plus a percentage" form of contract, the contractors were to submit to the Government, for investigation and approval, on the 25th of each month, a complete statement of all expenses incurred on account of the work for the previous month, including pay rolls, canceled accounts, vouchers and all other statements. This would mean that all the accounts pertaining to the "thousand and one" kinds of expenditure natural to a work of such magnitude and character would have to be prepared in quadruplicate in English and Spanish. This would require a large clerical force for the contractors, and the Government in turn would have to employ accountants to examine this large mass of data each month. This would naturally have caused confusion, misunderstanding and serious delays in effecting payments.

It was then decided to change the contract to a "fixed sum" form of contract, using the same estimate of cost as provided for in the original contract, together with the original specifications. The Government would then have the assurance and satisfaction of knowing that the railway would be completed according to specifications for a guaranteed fixed sum and, if the cost exceeds the contract price, the contractors assume this excess for their account.

The estimated cost or "fixed sum" was $1,628,141, or about $32,563 per mile. Later it was decided to build the Potrerillos Line of seven miles, build a 410-ft. span wagon bridge, repair several wagon roads and bridges and construct 50 miles of telephone and telegraph line to aid traffic and operation. This additional work was done at actual cost, with 5 per cent of the cost to go to the contractors for doing the work. This additional work brought the total cost up to a little over $2,000,000.

The contract time for completion was May 1, 1916, but on account of the extra work and heavy rains it was not completed until July 1, 1916. The completed railroad is as well constructed and equipped with rolling stock, shops and station buildings as the average railroad in the United States. The cars are of sufficient capacity to handle the traffic and the railway as a whole will answer all purposes for which it was built as well as would a standard gage railroad. The saving in cost in construction and equipment of a narrow gage railroad compared with a standard gage is not as great as many engineers may believe. The principal saving is in the cost of ties, ballast, excavation and bridges, the total saving being approximately only 6 per cent.

METHODS AND COSTS OF LOCATION SURVEYS FOR THE LITTLE RIVER DRAINAGE DISTRICT, MISSOURI.

Contributed by B. F. Burns, Office Engineer, Little River Drainage District.

What is the proper size of parties for field location on drainage work? What is necessary in the way of camp equipment? What can be reasonably expected in the way of miles of located line per week and what are the costs of such work per mile? These are questions which naturally arise when work of that kind is projected and the installation of field parties contemplated. It is the purpose of this article to describe briefly the location work of the Little River Drainage District, the methods used in handling that work, and costs.

Prior to beginning the location on the 624 miles of drainage ditches and the 30-mile diversion works some preliminary work had necessarily been done in the field. The line of the diversion channel had been run out, several circuits of levels lines had been run to establish bench marks where they could be easily picked up in the work that was to follow; compass and level lines had been run across the district east and west at intervals of one mile, generally on section lines, for the purpose of developing the general surface of the land. The locations of the ditches were determined from the developments of these last mentioned surveys. It was desirable to so locate the ditches that they would not cut up property and, unless absolutely necessary to do otherwise, the ditches were located on the section, half or quarter section lines.

The preliminary work was done some time—possibly four or five years—before the location work was begun. In the interim the district had been fighting its legal battles and, all cases bearing upon the legality of the organization and its right to proceed with the construction of the works described in its plan for drainage having been disposed of, the time for letting the work was set and parties assembled for the field location of the works.

The chiefs of party, levelmen and rodmen were, for the most part, gotten in touch with through a western agency and while, with few exceptions, the men were capable and did the work acceptably and well, experience has taught that a greater number of men with a wider range of experience can be reached through the medium of an advertisement in the widely read engineering journals.

Four field parties were organized. The regular party consisted of 10 men: chief of party, levelman, rodman, 2 chainmen, stakeman, 2 axemen, teamster and cook. To one of the parties it was necessary to add a compassman, as the uncertainty of the land lines made it necessary for the chief of party, assigned to that portion of the work, to do considerable scouting.

The parties were all equipped and supplied before leaving headquarters. The following camp equipment was allotted to each party:

1 cookstove.
1 2-gal. oil can.
4 frying pans.
2 skillets.
3 breadpans.
2 dishpans.
4 kitchen spoons.
3 pepper boxes.
3 salt boxes.
2 kitchen forks.
2 butcherknives.
1 cleaver.
1 flour sifter.
4 lanterns.
1 dipper.
2 doz. tin plates.
1½ doz. knives and forks.
1½ doz. teaspoons.
1 doz. tablespoons.
6 yd. toweling.
1 doz. tin cups.
3 tents and flies.
1 doz. cots and mattresses.
4 camp chairs.
2 doz. blankets.
1 doz. comforts.
3 heating stoves.
3 lamps.

General instructions relative to carrying on the work were given in writing and these were supplemented by specific directions relating to the particular work assigned to each party.

The chief work of the parties was to locate the lines, which were described in the Plan for Drainage. In each case the starting point was definite and from it the lines were run to follow the described course. As often as possible ties were made to section corners and if the line run was within 100 ft. of the true location at the tie the correct location was marked by offsetting at each quarter mile, driving hubs and blazing trees so that the hubs might be readily found later. Should the line fall more than 100 ft. from the true location at the tie it was rerun.

Levels were run over the compass lines and bench marks established each quarter of a mile.

Full descriptions of the trees blazed were recorded in the compass notes and descriptions of all bench marks were given in the level notes.

Profiles were platted in camp on hard paper, tentative grade lines laid down and the alignment platted at the bottom of the profile. These field profiles and the level notes were sent to the chief engineer at the close of each week. There the level notes were checked, complete profiles platted, and the notes returned to the party with corrections of any errors noted on them. Field profiles were platted in pencil only and with the exception of the alignment, which was traced onto the complete profiles, were used as a check against the work. Complete profiles were platted on transparent paper and in addition to showing the surface and grade lines give elevations on the grade lines at each point where the elevation changes one-tenth, the depth of cutting at each station—worked out from deducting the surface elevation recorded in the level notes from the grade elevation at each station—together with descriptions of the bench marks established, and the alignment.

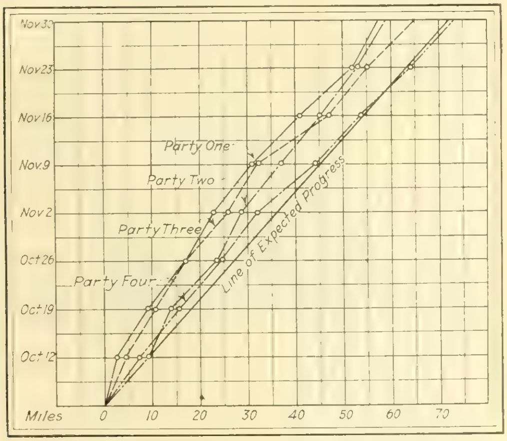


Fig. 1—Chart Showing Weekly Progress of Location Parties.

At the end of each week each chief of party furnished a report of his progress on a prepared form. This outlined the work of each day and delays. From these reports a chart of the progress was platted to show what each party did in comparison with the expected progress. Blueprints of this chart were sent to each chief of party. Special efforts were commended and an explanation of unsatisfactory progress requested, if it had not already been made on the weekly report. These stimulated the parties somewhat and brought forth an effort to make the best possible showing consistent with thoroughness and accuracy.

Practically all supplies for the sustenance of the parties were requisitioned from the chief engineer. Where farm products were available they were purchased at the direction of the chief of party, but the general purchasing of supplies was discouraged because of a tendency to over buy or to buy luxuries not in keeping with the plan of plain fare and good health. At the close of each month a full report of all supplies received during the month, used, and on hand at the beginning and end of the month was furnished by each party. From these reports the cost of sustenance per mile and the cost per day per man was figured and tabulated. The following shows the poorest showing, the best showing for one month and the final showing at the completion of the location work:

THE LITTLE RIVER DRAINAGE DISTRICT.
Monthly Report of Supplies for Sustenance.
Party No. 2.

Articles.	Ono Hand First of of Month. Lbs.	Received During Month Lbs.	Used During Month. Lbs.	On Hand Last Day of Month. Lbs.
Hams	25	115	120	20
Breakfast bacon	10	45	51	4
Navy beans	5	20	15	10
Rice	3	10	10	3
Coffee	5	5	7	3
Sugar	10	20	15	15
Corn meal	15	45	30	30
Flour	80	40	100	20
Lard	12	20	18	14
Molasses	1*	2*	3*	
Table salt	[illegible]		1	2
Black pepper	½		¼	¼
Vinegar	1		½	½*

*Gallons.

W. D. WATTLES, Assistant Engineer.
For the month ending December 14th.

Fig. 2—Monthly Report of Sustenance Supplies.

MONTH ENDING OCTOBER 15.

Party No.	Miles located.	Total payroll.	Labor per mile.	Sustenance cost.	Sustenance per mile.	Days worked.	Sustenance cost per man per day.
1	5.2	$211.29	$40.77	$ 76.26	$14.77	116	$0.6575
2	12.09	200.66	16.59	57.97	4.80	103	.3601
3	6.83	180.89	26.49	51.53	7.54	99	.5200
4	10.59	254.30	23.16	76.37	7.21	121	.6310
	34.71	$847.83	$21.55	$263.13	$ 7.55	439	$0.6971

MONTH ENDING NOVEMBER 15.

Party No.	Miles located.	Total payroll	Labor per mile	Sustenance cost.	Sustenance per mile.	Days worked.	Sustenance cost per man per day.
1	32.90	$ 516.36	$15.69	$113.63	$3.45	289	$0.393
2	33.64	518.97	15.40	118.67	3.53	301	.394
3	34.17	451.27	13.21	75.29	2.20	272	.276
4	40.28	598.79	14.86	63.02	1.57	303	.208
	140.99	$2.085.39	$14.78	$360.51	$2.18	1,165	$0 309

FINAL ACCUMULATED FIGURES.

Miles Located.	Total Pay Roll Expense.	Labor per Mile.	Sustenance Cost.	Sustenance per Mile.	Days Worked.	Sustenance Cost per Man per Day.
608.1	$11.595.34	$19.06	$2,611.08	$4.30	6,145	$00425

The expense for the month ending Oct. 15 was effected by the initial move from headquarters to the field and further by the fact that the parties were not yet thoroughly familiar with the work at hand, having been in the field but 10 days.

The organization as originally planned for the field work was maintained for a period of three months when, because of the lowlands filling up with water to a depth that work was not possible, three of the parties were taken off. The remaining party completed the work, or as much of it as it was necessary to complete at that time, and the accumulated figures above represent the costs of the field work at the time that party was taken off in November, 1913. The remainder of the line which remained unlocated at that time was portions that it had

THE LITTLE RIVER DRAINAGE DISTRICT
ASSISTANT ENGINEER'S WEEKLY REPORT.

Mr. Wm. A. O'Brien, Chief Engineer,
Cape Girardeau, Mo.

Following is a report of work done by Party Three during the week ending Sunday December 14th.

Sunday—No work.
Monday—Ran Ditch 1, Sta. [illegible], and Ditch [illegible], Sta. [illegible]-618.
Tuesday—Ran Ditch [illegible], Sta. [illegible], and ½ mile of tie line.
Wednesday—Ran Ditch 37, Sta. 543-570, and corrected No. 1, Sta. 600-610
Thursday—Moved camp. Ran Ditch 42, Sta. [illegible].
Friday—Ran Ditch 42, Sta. 638-670, and Ditch 43, Sta. 0-30.
Saturday—Ran Ditch 43, Sta. 30-75, and 1 mile tie line.

SUMMARY

Miles Random Line..[illegible] miles   Total to date........[illegible] miles
Miles Located Line..5½ miles   Total to date........81¾ miles
Total [illegible]   Total [illegible] miles

REMARKS

Water rising rapidly in low spots, almost too deep to wade in hip boots.

Signed JNO. B. JONES,
Assistant Engineer.

Fig. 3—Weekly Report Form for Assistant Engineers.

not been possible to locate because of water conditions and the location of which could be deferred until the construction work had begun and residencies for the supervision of that work organized.

The successful and economical handling of location work depends upon having the work of each party completely mapped out in advance; securing men as chiefs of party who have had some experience in work of like nature and who can effect an organization and maintain it in the field; providing instructions that are brief but explicit and allow the chief of party some latitude wherein to use his best judgment should extraordinary conditions arise; by exercising a reasonable control over camp expenditures for sustenance or otherwise, and last, but not least, enforcing absolutely a "no booze" rule upon each and every member of the parties.

For the location work practically all the forms were made on a hektograph, using special typewriter ribbon. They were made in the office as required at practically no additional expense. Figure 1 is a chart showing the weekly progress of the location parties. Figure 2 is a monthly report of the supplies for sustenance. Figure 3 shows the form of weekly progress report.

GRAVEL DIPPING: AN OPPORTUNITY FOR SMALL CONTRACTORS.

"Gravel dippers," or contractors making a business of "dipping" gravel for other contractors, railways, townships or road commissioners have increased in number in the last few years. The perfecting of the dragline cableway excavator gives them the means of equipping at very reasonable cost a portable plant which will dig gravel either from a dry pit or from a creek bed and produce from 150 to 400 cu. yd. a day, according to the size of the excavator bucket.

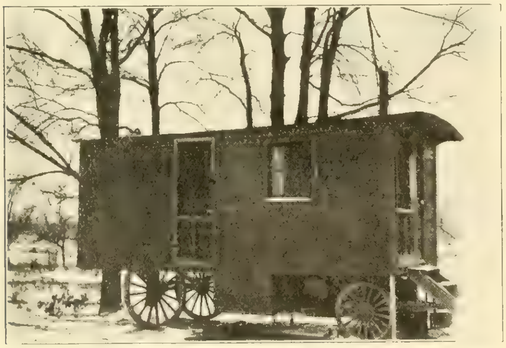


Fig. 1—Camp Car.

The common form of gravel plant is the "bar-run" outfit. This consists of the excavator bucket, cables, mast and engine, digging the gravel from a pit or creek-bed and depositing it in a pile. A 1-yd. bucket is ordinarily used and is generally operated by an 9x10 double-drum steam hoist, or 75 hp. electric, although smaller engines will suffice. By mounting the engine on wheels, and carrying the bucket and cable in wagons, the outfit can be moved from place to place and contracts from 5,000 cu. yd. and up can be handled very profitably.

Greater profits are possible where a "gravel dipper" obtains several large contracts in one locality and establishes a semi-permanent plant. A typical example is a plant near Cambridge City, Ind., recently set-up by J. W. Gwinn, a contractor of Lapel, Ind., who has traveled for several seasons through southern and central Indiana with a portable outfit, consisting of a bucket, hoist, cableway, traction engine and the camp car shown in the accompanying illustration. Two wagons were used for carrying the cable and bucket; the hoist was mounted on wheels and the whole outfit was hauled by the traction engine which also operated the hoist at other times.

Mr. Gwinn now has two contracts amounting to over 100,000 cu. yd. for furnishing ballast to the Indianapolis, Terre Haute & Eastern electric railway running through Cambridge City and for washed gravel for a concrete road job in the same vicinity. Using the 1-yd. Sauerman bucket, 8x10 double-drum, two-speed Thomas hoist, 500-ft. Sauerman cableway and other equipment of his portable outfit, he erected the plant shown in Fig. 2. It has a capacity of about 300 cu. yd. in a 10-hour day.

The total investment in the plant approximates $7,000. Daily operation costs are as follows:

Engineer	$ 4.00
Fireman	3.00
Laborers	4.00
Coal	3.00
Oil and miscellaneous	1.50
Total	$15.50

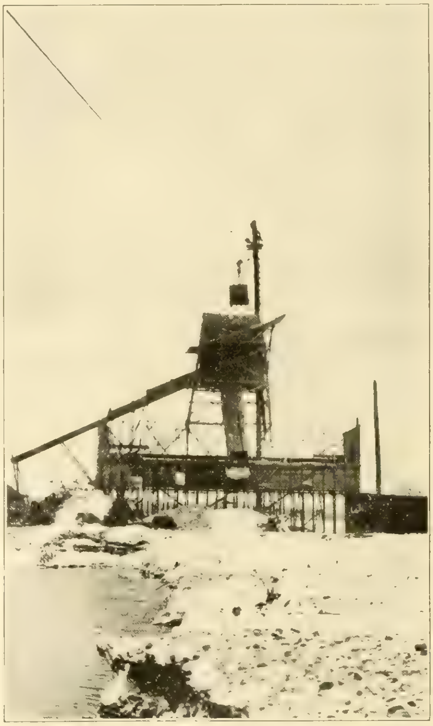


Fig. 2—Gravel Plant Near Cambridge City, Ind.

This shows a cost of 5 ct. per yard. But the yearly overhead charges should also be taken into consideration. They are as follows:

	Per year.
Interest on $7,000 at 6 per cent	$ 420
Renewal of cables, blocks and sheaves	400
Depreciation of engine and bucket	450
Total	$1,270

Counting on 200 working days, the daily fixed charges will be $6.30, which, added to the pay roll, gives a total daily expense of $21.80. This means that when the plant is working to capacity, gravel which sells for 25 ct. a yard costs only 7 ct. to produce.

The difficulty is that conditions constantly intrude to prevent operating the plant at capacity. Lately, Contractor Gwinn has suffered from the car shortage and was compelled to cut the daily operating hours more than one-half.

Granting that delays, car shortage, stops for repairs, etc., in the course of a year reduce the average daily output to 200 cu. yd., the cost per yard mounts to 10 ct., which still leaves a good margin of profit.

STEAM RAILROAD ELECTRIFICATION.

At the present time there are over 2,000 miles of electrified steam railroad track in this country. A brief review of the principal electrifications was given by Mr. J. A. Shaw, General Electrical Engineer of the Canadian Pacific Ry., in a paper presented Dec. 12 before the Canadian Railway Club. The matter in this article is taken from Mr. Shaw's paper.

Baltimore Terminal of Baltimore & Ohio R. R.—The first undertaking of this kind which could be classed as heavy electric traction was the Baltimore terminal at the Baltimore & Ohio R. R., which has been operated electrically since 1895.

The electric zone of the B. & O. R. R. lies entirely within the city limits and is a part of the so-called belt line extending from Camden Station on the west to Waverly interlocking tower on the east, a distance of 3.75 miles. There are eight tunnels in this zone which together constitute 48 per cent of the total distance. The longest of these tunnels is 7,300 ft. in length and extends from Camden Station to Mt. Royal. Needless to say, the change to electric haulage was made to eliminate the smoke and dangerous gases in these tunnels. As a matter of fact, however, the ordinance governing the construction of certain of these tracks through the city required that they be operated electrically.

The part of the zone through which trains are handled by electric locomotives is entirely up-grade, averaging 9 per cent with a ruling grade of 1.5 per cent. Trains are handled electrically only in the up-grade direction, the locomotives returning light. Regular service was started with three locomotives, weighing 96 tons each, equipped with gearless motors. Four additional locomotives of the geared type were put in service in 1903, one in 1906, and four more in 1910 and 1912.

New York Central Terminal.—The second steam road electrification and, perhaps, one of the most important in the United States, was the New York Central Terminal, initial operations being started the latter part of 1906. The present electric zone includes 251 miles of track equipped with underrunning third rail distributed over about 53 miles of route. All through passenger trains are handled by electric locomotives within the electric zone, the change being made at Harmon on the main line, about a mile south of Croton, and at North White Plains on the Harlem Division. Suburban passenger traffic is handled by multiple unit trains. As on the Baltimore & Ohio electrification 600 volts is used on the third rail, power being generated in depulicate steam turbine stations, one located at Port Morris on Long Island Sound, and the other at Glenwood near Yonkers on the river front. Each plant contains four 5,000-kw. Curtis steam turbine generating units delivering 25-cycle, 3-phase current at 11,000 volts.

This current is distributed over a 11,000-volt transmission to nine synchronous converter substations aggregating over 40,000 kw. In some of the earlier substations, storage batteries are also used as a reserve and to take peak loads.

Operation was started with 35 115-ton electric locomotives of the gearless type supplemented within a few years by 12 additional units of similar design. In 1913 and 1914, 16 additional locomotives of a new design were put in service. These machines are also equipped with gearless bipolar motors, but are constructed with eight driving axles instead of four, and the capacity is considerably greater than the original type. The last six locomotives, weighing 133 tons each, are probably the most powerful electric locomotives ever used in passenger service. They are capable of hauling 1,200-ton passenger trains on level track at nearly 60 miles per hour. These trains are also hauled at reduced speed up the 1.1 per cent grades leaving the Grand Central Terminal. On account of the gearless construction of the motors they operate at appreciably higher efficiency than geared designs. It has also been found that the maintenance is very low, averaging on the entire equipment during eight years of service approximately 3⅛ ct. per locomotive mile.

In order to take care of high speed express and local suburban service, multiple unit cars are employed on both the White Plains and the Harlem Division. Local service requires trains of from 2 to 11 cars, usually made up in the proportion of two motor cars to one trailer. Suburban express trains are made up of from 2 to 10 motor cars. These trains are capable of reaching a speed of over 50 miles per hour and are very flexible in terminal operation, since they can be run in either directions with equal facility. There are now in service 192 motor cars and a number of trailers, each having a seating capacity of 64 passengers. These cars are equipped with Type "M," Sprague General Electric control and two G.E.-69-200-h.p. motors. They are of all-steel construction, 60 ft. long and weigh approximately 57 tons completely equipped.

Well equipped repair shops are maintained at Harmon and at North White Plains, where both locomotives and multiple unit cars are inspected and repaired. The electrical equipment in this terminal service has shown remarkable reliability, there being very few interruptions to traffic from electrical causes. No interruptions whatever to traffic have occurred from power station troubles during 8 years of operation.

New York, New Haven & Hartford R. R.—The well-known installation which this railway carried out shortly after that of the New York Contral Ry. now consists of a total mileage of 500, and includes 61 miles of 4-track and 6 miles of 6-track right of way. There are 100 passenger, freight and switching locomotives and 69 multiple unit cars in service, which relieved 150 steam locomotives. The power service was formerly supplied from a single power house, but is now supplemented by a purchased supply from one of the New York power companies at the eastern end of zone. Certain of the passenger locomotives average 500 miles daily, and are in continuous service 24 hours daily for 30 days. In the case of switching locomotives a large number are now used in the yards of system, four electric units having been found to displace six freight switchers, principally on account of the fact that the electric switchers can be used almost continually with no lay-over periods. The equipment on this railway was made more complicated than on any other electrified railway, due to the fact that apparatus was required to operate from alternating current on the main system and from direct current supply when within the New York terminal zone. Probably more information has been obtained in guiding electrical engineers on the design of electric railway equipment for heavy service through the work carried out on this railway than in any other similar project, and the electrical profession is under a heavy debt to the New Haven Co. in this opportunity, as otherwise progress would have been greatly retarded without this undertaking.

West Shore R. R.—Shortly after the New York Central terminal electrification was completed, an electrification project was undertaken by the West Shore R. R., a subsidiary of the New York Central system. On account of the parallel trolley lines it became necessary for this road, operating between Utica and Syracuse, to increase the capacity of the road and to develop a high-speed passenger traffic over the portion of its tracks between these two cities. The electrified section of the road is double-tracked throughout and a third and fourth track is provided at some points to enable steam trains to pass the multiple unit trains. The distance between terminals is 44 miles with a total mileage on a single-track basis of 106 miles. Formerly, only two steam passenger trains were run daily in each direction and at night two trains of sleepers passed over the tracks. With these tracks electrified there are fast limited cars hourly from each terminal, local cars or trains once an hour from each terminal and also a fast freight service which is still hauled by steam locomotives.

The electrified division is equipped throughout with an underrunning third rail similar to that used on the New York Central terminal electrification, current being fed from synchronous converter substations at 600 volts.

Power is received by four substations from the Adirondack Electric Power Corporation at 60,000 volts. Each substation contains two synchronous converters of 300-kw. capacity, each with reserve space for an additional unit.

The rolling stock equipment includes 19 four-motor multiple unit cars, which are operated either singly or in trains as the traffic requires.

It is interesting to note that with the third-rail construction used this line has never been seriously handicapped by snow. Interruptions to the service from all causes have been practically negligible and the traffic of the system has shown a steady growth.

West Jersey & Seashore R. R.—One of the earlier railroads to take advantage of electrification as a means of increasing facilities for handling passenger traffic was the West Jersey & Sea Shore Division of the Pennsylvania System, extending from Camden to Atlantic City, a distance of 65 miles, and a branch from Newfield to Millville, a distance of 10 miles. The contract for the entire equipment of this railroad, including installation and the equipment, was placed in service in a little over five months, which is a remarkable record considering the fact that included in this work were the erection of a power station, eight substations and the electrical equipment of over 150 miles of single track, the building of 71 miles of high-tension transmission in duplicate and the equipment of 68 multiple unit cars. The line from Camden to Atlantic City is double-tracked throughout and at points there are three tracks. With the exception of a short stretch of track near Camden, the entire road is equipped with an overrunning third rail operating at 600 volts and taking power from the synchronous converter substations. Multiple unit equipment is operated in trains of from 3 to 10 cars without trailers. The express service between terminals operates on a headway of 15 minutes in each direction at speeds up to 60 miles per hour. Frequent local service is also provided for Camden suburbs and on the branch line to Millville.

Electricity is generated in a steam turbine station at Westville, generating 6,600 volts, 3-phase, which is stepped down and delivered from the synchronous converters at 650 volts to the third rail.

The power station equipment consists of three 2,000-kw. Curtis turbo-generators with the necessary auxiliary units. Each of the substations is equipped with two 750-kw. synchronous converters with space for an additional unit.

The present rolling stock equipment consists of 109 motor cars, some of which are constructed from combination baggage and smoking cars, and others for mail cars. Each is equipped with two 200-h.p. motors and Type "M" automatic control. The standard passenger cars have a weight of about 45 tons and a seating capacity of 58 persons.

The operation of this electrified steam road has been most satisfactory in every way. The number of delays chargeable to electrical equipment has been less than 6 per cent of the total number of train minutes' detention, and the increase in traffic gained by the use of multiple unit cars instead of steam trains has enabled the railroad to make a remarkable increase in the number of passengers carried, on account of the local service furnished to the smaller towns and the high-speed express service between terminals.

Great Northern Ry.—Cascade Tunnel Electrification.—One of the most unique electrifications in the country and the only road to use 3-phase equipment is the Cascade Tunnel on the Great Northern Ry. near the summit of the Cascade Mountains, in the State of Washington. This tunnel is 14,000 ft. (2.65 miles) in length and has a uniform grade of 1.7 per cent. In the yards at each end of the tunnel are grades of 2.2 per cent, on which all trains must be started.

Under steam operation this tunnel had become the limiting feature of the road. Heavy freight trains, requiring from two to four of the heaviest locomotives, could not operate trains faster than from 7 to 8 miles per hour. In the tunnel operation was still more difficult. The smoke and steam coated the rails with damp, greasy soot causing the wheels to slip and the smoke and gases made operation positively dangerous to train crews.

The electrification involved about 4 miles of route with 6 miles of single track, including sidings. Power is generated in a 5,000-kw. hydro-electric plant at Leavenworth, transmitting 3-phase, 25-cycle current at 33,000 volts a distance of about 30 miles. The contact system consists of double trolley construction carrying 3-phase, 6,600 volts A. C., using the rail and ground return for the third conductor. These overhead wires are spaced about 8 ft. apart in the tunnel and 5 ft. apart in the yards. Ordinary pole trolleys are used for collecting the current.

There are four electric locomotives weighing 115 tons each, all of which is on the driving axles. Three-phase induction motors are connected by twin gears to each axle and the trucks are adequately equalized to take care of twisting strains. These motors are of the 3-phase induction type wound for a primary voltage of 500, the rotors being equipped with wound secondaries brought out through collector rings. There are 13 steps in the resistance used in connection with the rotor, allowing for ample speed control. The average freight train hauled weighs approximately 2,000 tons, including both steam and electric locomotives. On down grades the induction motors automatically return power to the system when the train exceeds the normal speed of about 15.5 miles per hour.

The Great Northern has the distinction of being the first railroad electrification in this country to use regenerative braking, this feature having been in very successful operation for more than six years. The Norfolk & Western Ry. has recently begun operation, using the same principle, and the Chicago, Milwaukee & St. Paul Ry. has adopted direct current regeneration.

This installation was made in July, 1909, and since that time all traffic through the tunnel has been handled by the electric locomotives, with the exception of delays due to avalanches and snow slides, some of which have interrupted traffic for several days at a time.

On March 1, 1910, an avalanche came down the mountain through the yards near the tunnel carrying all the coaches of two trains with two steam and three electric locomotives down into the bottom of the canyon, from 200 to 400 ft. away.

The electric locomotives were untouched for about three weeks during the task of clearing the line. They were then taken to the railway company's shops and put in operating condition. It is worthy of note that the average cost of repairs, including labor and materials on the three electric locomotives, was $962 each, while the expense of similar repairs on the two steam engines was $1,284 each.

St. Clair Tunnel Electrification.—The Grand Trunk Ry. in May, 1908, replaced four steam locomotives of 100 tons with six 66-ton electric units, which, as a rule, are used in sets of two. During the period that these electric units have been in service no failure has yet occurred in the main motors, and they have been available for service throughout 90 per cent of the time. The average annual cost for the maintenance of the four steam locomotives was $21,173, while that for the six electrical locomotives has been $11,131. The average cost per car handled through the tunnel, a distance of approximately five miles, by steam locomotives was 26.6 ct., as against 17.2 ct., by electrical locomotive, although the capacity of cars handled today is much greater than the capacity of those of 1907 and 1908. The cost of fuel for the steam locomotives was $42,000 per year, whereas the average cost of fuel consumed for generating energy for the electric locomotives is $17,000 per year. This difference in cost is partly due to the fact that slack coal is now used, whereas hard coal was used for the steam locomotives. Power is supplied from one plant containing two 1,500-h.p. turbo-generator sets, and stokers of boilers are so controlled that their operation is practically controlled automatically from the operation of locomotives on the main line.

Detroit River Tunnel Electrification.—One of the most successful electrifications of a trunk line steam railroad is the section of the New York Central system now operating under the Detroit River. The 2-track tunnel connecting the lines of the Michigan Central R. R. terminating at Windsor, Ontario, and those in the United States, terminating at Detroit, was completed in 1910, and since that time all trains have been hauled by electric locomotives through the tunnel instead of being ferried across the river. Under the old method it required about 30 minutes to make the crossing and the facilities were very limited. With the tunnel, however, trains pass through in less than six minutes, and the capacity of the tracks is limited only by the length of train which can be handled. The general scheme of electrification includes the purchase of 3-phase, 60-cycle energy at 4,400 volts from the Detroit Edison Co. and transformation in the company's substation to 650 volts direct current. At this voltage current is fed to the locomotives through an underrunning protected third rail reaching all of the electrified tracks.

The substation is located near the Detroit end of the tunnel and contains two 1,000-kw. synchronous motor generator sets with auxiliary equipment for excitation and for controlling a 312-cell storage battery (capacity 630 amperes, for 8 hours, and momentary discharges up to 11,000 amperes). The control equipment is so arranged as to reduce the peak loads and thus obtain a practically constant load at unity power factor.

The original equipment consisted of six electric locomotives designed for hauling both freight and passenger cars through the tunnel and also for switching service in the yards. Each is equipped with four railway motors and weighs 200,000 lb., all of which is on driving axles. The service consists of hauling an 1,800-ton trailing train from one yard to the other, negotiating a 2 per cent grade when two locomotives are operated multiple unit. The second order of locomotives placed in service in 1914 consisted of four similar units, each weighing 240,000 lb. The total electrified trackage now in operation is approximately 24 miles, including yards on both sides of the river and the two-track tunnel.

Norfolk & Western Ry.—The electrification of 30 miles of this road was the solution of the problem to double the capacity of a hilly section with a tunnel. The limit in capacity by the use of the heaviest steam power had been reached, and continual delays were being met with through the severe starting difficulties on grades. The latter condition arose partially through necessary stops for coal or water. Twelve electric locomotives have displaced 33 Mallet locomotives, and have increased the average speed up the ruling 2.4 per cent grade from 6 to 14 miles per hour. The principle of braking by regenerating power has proved a complete success on this railway. The fact that the speed on down grades is constant and inflexible prevents the possibility of surges in the train which would result in broken drawbars. The main electrical feature in this electrification was the application of the polyphase induction type of motor to locomotive axles and the use of a converter on each locomotive so as to permit operation by single phase alternating current, and thus permit of the advantages of a single trolley wire. Trains are operated with one locomotive hauling and a pusher on the heavier grades. The method of starting is for engineer on the head locomotive to release brakes and let the slack run back. As soon as the engineer on the pusher feels the resulting blow, he applies power and holds the train till the front man gets under way. This method is due to the two men not being able to signal due to curves and train length and works out very satisfactorily.

Suburban Lines of the Southern Pacific Co.—Oakland, Alameda & Berkeley Divisions.—The suburban lines of the Southern Pacific Railroad Co., in the immediate vicinity of San Francisco, were changed over from steam to electric operation in 1911. The electrified district includes what is known as the Oakland, Alameda & Berkeley Divisions, which carry the heavy suburban traffic from the ferries to the residential districts.

Power is generated for this system in an oil burning steam station located at Fruitvale, the generating units consisting of two 5,500-kw. turbo-generator sets delivering 3-phase, 25-cycles. Power is transmitted at 13,200 volts to two outlying substations, the third being located in the power house. Each of the substations is equipped with two unit synchronous converter sets operating two in series for 1,200 volts. Each of these sets is of 1,500-kw. capacity, there being in all 10 double units in the three substations.

The rolling stock equipment consists of 81 all-steel multiple unit cars, each equipped with four 145-h.p. 600/1,200-volt motors. Trains of from 2 to 12 cars, made up of motor cars and trailers, are operated, depending upon the demands of the traffic.

The contact system on the Southern Pacific lines is of a flexible type built for the use of pantograph trolleys.

Pennsylvania R. R.—In addition to the direct third rail electrification of its New York entrance, this railway has recently electrified suburban lines operating out of the Philadelphia Broad Street Station. This station when completed, in 1881, contained 8 tracks and handled 160 trains each day, with 18 trains in the rush hour. In 1910 tracks had been increased to 16 and trains to 574, with 53 in the rush hour. Electrification has given relief by reducing the train movements, averaging from 4 to 15 down to 2. This was achieved by the use of 93 motor cars. Up to the present, trains of these cars are only running on one division, but this will shortly be increased. It is found, due to the higher rate of acceleration possible, that these trains can be more quickly dispatched, this permitting reducing running time considerably. Each car has two 225-h.p. motors and an 8-car train is found to draw 6,800 h.p. when accelerating. The fluctuations in power demand for present service varies from 27,000 h.p. to zero, averaging 8,000 h.p. per hour during the rush period. The power demand in this service is, therefore, not only considerable, but very fluctuating. Power service is purchased from the Philadelphia Electric Co.

Butte, Anaconda & Pacific R. R.—The Butte, Anaconda & Pacific Ry., which began electrical operation in 1913, is in many ways one of the most remarkable examples of electric train haulage in this country. While previous examples of steam road electrification have been equipped for various reasons, either tunnel and terminal operation or for high-speed suburban service, this road was electrified purely for reasons of economy. The results of this changeover have amply justified the initial cost of the electrification, a comparison of operating results during the first six months of electrification showing a saving of an amount equal to 20 per cent of the initial cost, not allowing any salvage for steam engines released.

The electrified tracks of this company consist of 30 miles of route between the mines at Butte and the smelters at Anaconda and about 114 miles on a single-track basis. Power is purchased from the Montana Power Co.'s extensive system at 2,300 volts, 60 cycles, and is transformed by motor generator sets to 2,400 volts direct current for use on the trolley. There are two substations, one located at Butte and the other at Anaconda, both of these being installed in the existing transformer stations of the power company. The initial rolling stock included 15 freight and two passenger locomotives, and eight additional locomotives have since been purchased to take care of the heavy increase in traffic.

The freight traffic consists largely of transfer of copper ore, and at present amounts to more than 6,000,000 tons per year. This material is handled in steel ore cars, having a capacity of about 50 tons each. The weight of train hauled over the main line, including a 3 per cent grade, frequently reaches 5,000 tons trailing.

Eight passenger trains per day are operated between Butte and Anaconda, each consisting of from three to five passenger and baggage cars.

The overhead construction on this system is made especially flexible by the use of loop hangers which allow the contact wire to rise without lifting the weight of the messenger. There also may be other novel features in the switching yards and at street railway crossings.

The eminently successful operation of this initial 2,400-volt railway was largely influential in the decision of the Chicago, Milwaukee & St. Paul Ry. to electrify its mountain divisions at 3,000 volts direct current.

Chicago, Milwaukee & St. Paul Ry. Transcontinental Electrification.—The Chicago, Milwaukee & St. Paul electrification differs from all previous projects of this kind in that the transcontinental lines involved embrace four complete engine divisions as operated by steam locomotives. None of the existing electrifications on trunk line railways, either in this country or in Europe, have included more than one engine division. For this reason there has been no opportunity for interchange of spare locomotives and no possibility of materially reducing the number of spare steam locomotives required for the operation of the system.

The Missoula and Rocky Mountain Divisions of the Chicago, Milwaukee & St. Paul Ry. include 440 miles of route, embracing approximately 650 miles of single track lying between Harlowton, Montana, on the east, and Avery, Idaho, on the west. This road is one of the main transcontinental highways of the country and the divisions being electrified contain the most serious grades encountered on the Chicago, Milwaukee & St. Paul Ry. between Chicago and the coast. Under steam operation these four divisions required 103 steam locomotives of the heaviest types, and even with this number of engines the schedule was maintained with difficulty. In the winter when temperatures range as low as 40 to 50° below zero, it is extremely difficult to keep steam locomotives in operation. It is no uncommon occurrence to find several locomotives stalled during cold weather, with fires drawn and water removed from the boiler, owing to the freezing of some of the piping which is exposed to the weather. Furthermore, it has been found that after hauling a train over a 112-mile division for about three days in succession it is necessary to put the locomotive into the shops for a day's overhauling.

The electrical equipment for this electrification includes 42 main line passenger and freight locomotives and two switchers, and experience with electrical locomotives on the first two divisions seems to indicate that these locomotives will be amply sufficient to take care of the present traffic and normal increase within the next few years. In addition, it is probable that trains will be operated much more nearly on schedule time and with less damage to equipment owing to accidents. In the operation of the first division it has been found that one electric is capable of easily replacing three steam engines, and possibly four, when other divisions are put in operation. The reasons for the much greater capacity of the electric locomotives per unit are: first, ability to operate a large per cent of the 24 hours with minor inspections; and, second, ability to haul equivalent trains at approximately double the speed of the steam locomotives. Many other advantages may be mentioned which tend to increase the capability of the electric locomotive as compared with the steam. Not the least of these is the regenerative braking feature which relieves the brakes of a large portion of the wear and heating due to holding heavy trains on severe grades.

The 440 miles of route involved in this electrification will be fed from 14 substations located at points averaging 33 miles apart, each station receiving power from the Montana Power Co.'s system at 100,000 volts and transforming to 2,300 volts for synchronous motor generator sets. These sets are of the three-unit type, consisting of a synchronous motor and two 1,500-volt direct current generators connected permanently in series to deliver 3,000 volts to the trolley. Each station contains either two or three of these sets, there being a total of 32 sets in the 14 substations. Two small generators, one on each end of the set, furnish exciting current for the main fields of the generators and for the revolving field of the motor. The substation equipment is so arranged that in case the regenerated power sent back by the locomotives exceeds that being used nearby, the motor generator sets will operate inverted and thus return excess energy to the transmission system and thence to other substations requiring power. Measuring instruments are arranged to credit the amount of this returned energy to the railway company. Each of the substations is in charge of three operators working on 8-hour shifts, and these men are at all times under the direction of the train and power dispatcher, who gives instructions for the operation of the station. Two model bungalows have been built by the railway company at each station for housing the operators.

As above mentioned, electric power is received at 100,000 volts, 60 cycles, from the transmission network of the Montana Power Co., operating numerous hydro-electric plants in various parts of the state. The largest of these stations are located at Great Falls and at Thompson's Falls. In order to insure power supply at all times there are several feeding-in points, and the railway company maintains a separate 100,000-volt transmission line the entire length of the electrification.

One of the most completely equipped hydro-electric plants on this system is the Volta plant, in the Great Falls of the Missouri River. This station at present contains four 10,000-kw. vertical generators and two additional units are being installed. The available head at this point in the Missouri River is 155 ft., and the supply of water at all times is ample.

The main line locomotives, a number of which are now in service, have a total weight of 282 tons with 224 tons on the driving axles. The cab consists of two similar sections extending practically the full length of the locomotive. The freight and passenger locomotives are similar in all respects, except that passenger locomotives are provided with a gear ratio permitting the operation of 800-ton trailing trains at approximately 60 miles per hour, and are furthermore equipped with oil-fired steam boilers for heating the trailing cars. Each locomotive carries eight 430-h.p. motors, each geared to a driving axle with twin gears. These motors are designed to operate at 1,500 volts per commutator, two motors being permanently connected in series across the 3,000-volt circuit. The tractive effort available for starting trains is approximately 135,000 lb. at 30 per cent co-efficient of adhesion, and the continuous tractive effort of the freight locomotives is 71,000 lb. In addition to the eight driving axles, each half of the locomotive carries a two-axle guiding truck which supports approximately 30 tons weight. The motors are ventilated by a forced draft from a blower, which is driven from the control motor generator set located in the cab of the locomotive.

The control equipment is the well-known type arranged for multiple unit operation. This allows two locomotives to be operated from a single controller. The main control switches are located in steel compartments inside of the cab, convenient for inspection and repairs. Current for operating contractors, lights and other auxiliary apparatus is taken from a 3,000/125-volt motor generator set, one of which is located in each half of the locomotive. Compressed air for the air brakes, whistles, pantograph trolleys and other auxiliaries is supplied by a 3,000-volt, two-stage air compressor having a piston displacement of 150 cu. ft. of free air per minute against a pressure of 135 lb. Current is collected from two pantographs, one located at each end of the locomotive.

One of the most distinctive features of this electrification is the regenerative braking on the locomotives, which permits the return of energy to the system on descending grades instead of checking the speed of the train by means of the air brakes. The amount of braking is directly under the control of the engineer, and the air brakes are relieved of practically all service except when bringing the train to a final stop. It should be understood that when braking a train by the regenerative method, there is no overheating as is the case with air brakes, and consequently there is a material reduction in the wear on brake shoes, tires and rails. In addition to this the air brakes will always be in good condition when required for emergency service and delays due to excessive wear will be greatly reduced. In actual practice it has been found that a large portion of the power regenerated by trains on descending grades is used up by other trains taking power on the level or ascending grades. In some cases when there is no train available for absorbing the excess energy the power is taken up by one or more substations and returned to the transmission system connecting the several substations.

The overhead construction consists of two 4/0 trolley wires flexibly suspended from a steel catenary supported on wooden poles. Bracket construction is used wherever the track alignment will permit and cross span on the sharper curves and in the switching yards. The two wires are suspended side by side from the same catenary by independent loop hangers alternately connected to each trolley wire. This type of construction permits the collection of very heavy currents by reason of the twin contact on the pantograph with the two trolley wires, and also insures sparkless collection under the extremes of either heavy current at low speed or more moderate current at high speeds. A 500,000 c.m. feeder parallels the track for about 80 per cent of the 440 miles, being used on all grades up to and including 1 per cent. On heavier grades a 1,000,000 c.m. feeder is used. A 4/0 negative feeder or ground wire is carried on top of the poles.

During the early part of December, 1915, an interesting comparative exhibition was staged by the Chicago, Milwaukee & St. Paul Ry. for the purpose of showing prominent officials the comparative capabilities of steam and electric locomotives. The observation party was stationed at Janney Substation, on the western slope of the Rocky Mountains and about midway on the 1.66 per cent ascending grade. The first train sent up the hill was hauled by one of the 282-ton electric locomotives, assisted by a similar unit acting as a pusher. The train consisted of 48 cars weighing approximately 3,000 tons trailing and negotiated the grade very easily at about 16 miles per hour. Following this was a second train hauled by two Mikado type steam locomotives and one Mallet steam pusher. The steam train consisted of 37 cars weighing about 2,200 tons and difficulty was encountered in making the grade at a speed of from 9 to 10 miles per hour. Upon completion of the test, President Earling indicated his entire approval of the electrical equipment and gave instructions for putting it into regular service immediately.

Time Required for Transit Through Panama Canal. The following tabulation from the Panama Canal Record shows the time required by the 158 transits through the canal in October. It will be noted that 89 of the ships, or more than half, were in the canal between 9 and 12 hours. The percentage requiring over 12 hours was 30.7, and the proportion passing through in less than 9 hours was 15 per cent. Detailed classification follows:

Time	Atlantic to Pacific	Pacific to Atlantic	Total	Per cent
Under 7 hours	[illegible]	[illegible]	[illegible]	[illegible]
7 to 8 hours	[illegible]	[illegible]	[illegible]	[illegible]
8 to 9 hours	[illegible]	[illegible]	[illegible]	[illegible]
9 to 10 hours	[illegible]	[illegible]	[illegible]	[illegible]
10 to 11 hours	[illegible]	[illegible]	[illegible]	[illegible]
11 to 12 hours	[illegible]	[illegible]	[illegible]	[illegible]
12 to 13 hours	[illegible]	[illegible]	[illegible]	[illegible]
13 to 14 hours	[illegible]	[illegible]	[illegible]	[illegible]
14 to 15 hours	[illegible]	[illegible]	[illegible]	[illegible]
15 to 16 hours	[illegible]	[illegible]	[illegible]	[illegible]
Over 16 hours	[illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]	[illegible]	[illegible]

The aggregate time of all the vessels was 76 days, 19 hours, 33 minutes, giving an average time for all the vessels of 11 hours and 40 minutes. The minimum time was 7 hours, 17 minutes. The maximum time was 1 day, 8 hours, 10 minutes.

METHOD AND COST OF STRIPPING IN THE ANTHRACITE COAL REGION OF PENNSYLVANIA.[1]

The equipment required for a one-shovel operation is about as follows:

1 70-ton shovel.
3 18-ton locomotives.
20 5-yd. dump cars.
1 star drill.
1 steam drill.
1 water tank.
1 boiler.
1 blacksmith shop.
Necessary rails, sills, pipe lines, tools, etc.

The total capital outlay for such an outfit is approximately $30,000.

The average force required to operate a one-shovel stripping consists of about 35 men, roughly as follows:

1 foreman.
1 shovel engineer.
1 craneman.
1 fireman.
1 watchman.
2 laborers.
4 brakemen.
3 locomotive engineers.
1 dump boss.
6 dumpmen.
1 track boss.
2 trackmen.
2 drillers, 8 helpers.
1 boiler fireman.
1 blacksmith & helper.
2 coal diggers.
1 driver.
1 switchboy.

The wages paid these men amount to $2,100 per month. The shovel engineer is paid $140 a month, the craneman $95; locomotive engineers $0.25 per hour. These rates are all subject, however, to the recent increases granted the mine workers, ranging from 7 to 15 per cent.

When a stripping is decided on and its limits staked out by the engineers, an inspection of the ground determines the method of opening it. Usually the cuts at the higher elevations are made first. After that the problem is almost entirely a transportation one. Steady operation of the shovel or shovels is the object to be secured.

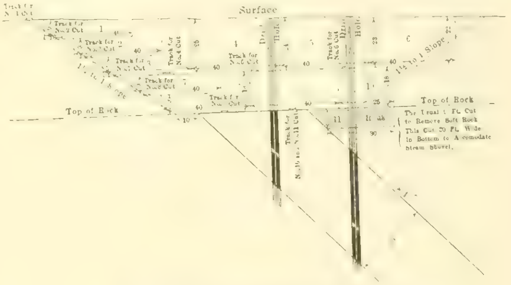


Fig. 1—Method of Opening a Stripping.

Everything must contribute to this end—tracks and rolling stock must be in good condition, turnouts must be maintained, and the grades must be as easy as the nature of the ground will permit. If in rock, drilling and blasting must be kept well in advance.

The method of opening a stripping with either a Bucyrus 70-ton shovel or a Marion 60-ton shovel, which are the two types most widely used in anthracite stripping work, is as follows (Fig. 1): For the first cut the track is laid on the surface along one limit of the stripping, usually the bottom rock side, and the shovel cuts down grade alongside the track until a depth of 9 ft. is reached, this being the maximum cut that the shovel can take and load overhead. When the first cut is completed for the length of the stripping, the track is laid in this cut and the shovel again cuts down grade until a depth of 9 ft. below the first cut is reached. The shovel then continues cutting toward the other limit, the additional depth being determined by the depth of surface over the vein up to 30 ft., which is considered the proper maximum height for a clay cut. In working by the above method, it is necessary to leave a bench at least 13 ft. in width for the laying of the track. Local conditions, as a rule, render it impossible to maintain any such plan for the entire life of a stripping.

The first cut as described above is always the first made in a stripping except in the case of what is known as a side-hill stripping. Here the track is laid on the surface and the shovel started at an elevation that will give the required cut at the vertical limit.

Rock cuts are usually made from 22 to 25 ft. in height, though more recent practice is to keep the height down to 12 or 15 ft. This height depends somewhat on the nature and hardness of the rock. The lower height seems better for very hard rock, the reason being that the rock is broken up by blasting better than in the case of a higher bank, especially the upper portion of the bank, and consequently is more easily loaded. A saving of 25 per cent in cost per cubic yard is claimed for this method.

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[1] [illegible] Lansford, Pa., Chief Engineer of the Lehigh Coal & Navigation Co., prepared for presentation at [illegible] Institute of Mining Engineers [illegible]

Drill holes for blasting are arranged in parallel rows, usually three, with the holes 12 to 20 ft. apart and the holes in each row staggered. From 15 to 25 holes are fired in a battery, or more if possible. After the holes have been drilled a charge of from three to eight sticks of 40 per cent dynamite is used to "spring" each hole. By "springing" is meant the blasting of a pocket at the bottom of the hole to take a sufficient charge of black powder. It is sometimes necessary to spring a hole two and three times. The charge of black powder then used varies greatly, according to the nature of the rock and the amount of powder that can be put into the hole. The pocket itself, and the hole for about 2 ft. above the pocket, is filled with powder and the remainder of the hole with clay or coal dirt.

For 25 and 30-ft. holes, "Star" type churn drills are usually used with a customary diameter of 4 in. In solid rock the progress is about 30 ft. per shift of 9 hours, or an average of 3⅓ ft. per hour. For holes 12 ft. deep or under, a steam tripod drill is used and about double the progress of the churn drill, or 6⅔ ft. per hour, is made.

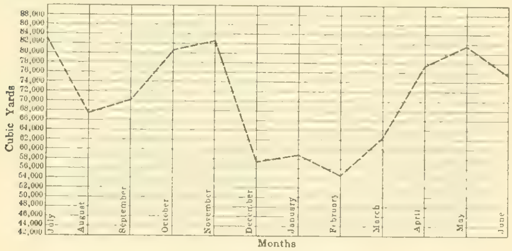


Fig. 2—Stripping Operations of One Company Averaged by Months Over Period of 4 Years.

Average costs for drilling and blasting are as follows per cubic yard of rock excavated:

Labor drilling and charging, depreciation equipment, etc	$0.045-$0.065
Powder	0.055- 0.080
	$0.100-$0.145

The tracks to the dump are always on an ascending grade of at least 1 per cent, though usually higher. Four per cent is common and grades as high as 7 per cent have been used. The grade of the tracks in the stripping pit is governed by the necessary rise in elevation to reach the dump. The locomotives used vary in size up to 20 tons, the latter being about the heaviest type that can be used safely on a dump of any height. A 20-ton locomotive will push:

10 4½-cu. yd. cars on a 1 per cent grade
8 4½-cu. yd. cars on a 3 per cent grade.
6 4½-cu. yd. cars on a 1 per cent grade.

The general, and best, practice for stripping tracks is to use 60-lb. rails and nothing under a No. 6 frog. Curves should be kept to under 10°, though 20 to 25° curves are used, especially in forming a dump.

Dumps are made of all heights and sizes, though there is less maintenance cost with heights of about 25 ft. Dumps of greater height settle and slip easily, especially in wet weather.

The cars most widely used in stripping work are the Eastern and Western type side-dump cars. The Eastern type is of 4½ to 5¼ cu. yd. capacity and the Western type of 4 cu. yd. Some 8 to 10-cu. yd. cars are in use and the results obtained seem to be satisfactory.

Under proper conditions, outputs as high as 30,000 cu. yd. per month have been obtained for one shovel in clay. The average, however, is only about 18,000 cu. yd. for clay varies considerably according to the season of the year, as is illustrated in Fig. 2.

If the stripping is not too deep, all the excavated material can be removed by locomotives. In many cases, however, this is not feasible and hoisting planes must be resorted to. Practically without exception, even in the largest operations, these are single-track planes operated by small second-motion hoisting engines with a capacity of about 150 dump cars per day, or about the output from one shovel. The practical problem involved in putting these planes down along the steep sides of the average pit is often a serious one. Some of the planes are anchored on a slope of 50° to 60° pitch by bars sunk into the solid rock to which the roadbed is tied, presenting a very interesting sight. While nothing can be said against these small hoists for a one-shovel stripping, it is undoubtedly bad practice to use them in the larger operations employing two or more shovels. There are practically none of these that cannot be laid out so that the output from two shovels can be brought to the foot of one plane, and this plane should be equipped with a hoist capable of handling with ease 300 and more cars per day. This plane can be either single track or double track, but the grade should be maintained at about 20°, which is the average for the single track planes now in use. Some figures have been worked up showing the comparison of the cost of the two varieties of planes, taking a double track plane handling only the output of two shovels which would allow the greatest advantage of comparison possible to the small hoist. The first cost of the small hoist job is very low, as the hoist itself is usually picked up second hand around the colleries. It would be something as follows for a 300-ft. length of plane:

Hoist	$ 500
Tracks, track material, rope, etc.	700
Grading for hoist and plane	1,000
Total	$2,200

For the double track plane with the larger hoist the figures would be:

Tracks, track material, rope, etc	$1,100
Hoist	5,000
Hoist house, pipe line, etc.	800
Grading for hoist and plane	3,000
Total	$9,900

To operate the single-track plane two top-men, two bottom-men, one locomotive engineer, one hoist engineer, four men and a boss on the dump, are required, while the double-track plane would require three top-men, three bottom-men, two locomotive enginemen, one hoisting engineer and seven men and one boss on the bank.

The comparative cost would be as follows:

	Single Track.	Double Track
Labor per day	$17.88	$26.21
Power	4.30	6.18
Interest and depreciation, 15 per cent	1.00	4.00
	$23.18	$36.69

Figuring 150 cars for the single-track plane, the operating cost per car would be $0.155 and at 300 cars for the double-track plane $0.122 or a difference of $0.033 per car.

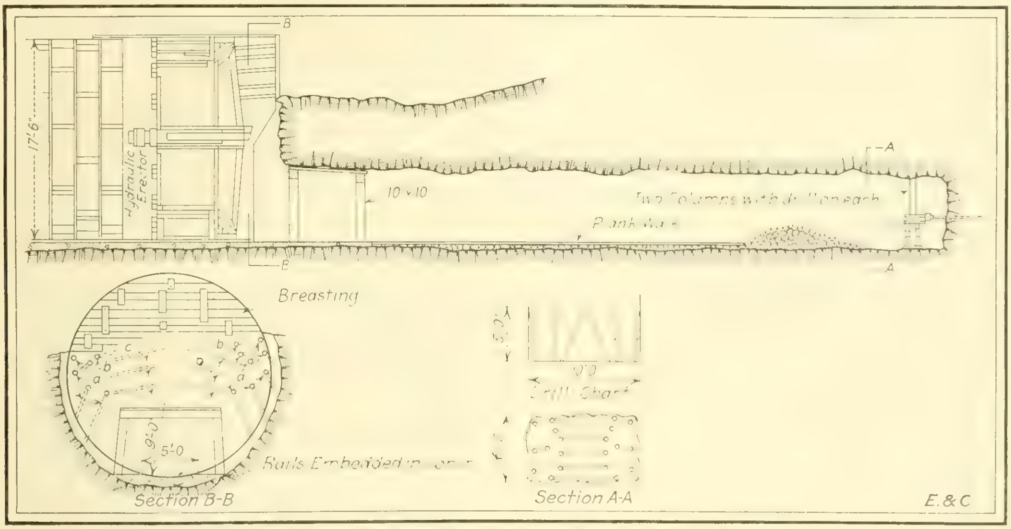
The location of the limits for a stripping are set on a line where the normal slope of the overburden figured from the bottom of the final cut intersects the surface. Naturally a shovel cannot cut to any such slope and must accomplish the same result by a series of steps. The normal slope that earth of a clayey nature will take is about 1 to 1. Sandy ground requires 1½ to 1 or even 2 to 1, while rock can be cut nearly vertically if the height of bank does not exceed one shovel cut. For greater depths, ½ to 1 must be allowed or even 1 to 1 if the rock is of a shaley nature. The importance of having the foot of the stripping slope well back from the bottom rock of the coal, to prevent the washing of overburden into the exposed vein by rains, is very great. The standard width for this ledge or berm is 10 to 15 ft.

An increase in car demurrage rates made with the approval of the Interstate Commerce Commission is now in effect. The receiver of a car load of freight now has two days' free time in which to unload. After this demurrage will be charged at the rate of $1 for the first day, $2 for the second, $3 for the third, $4 for the fourth and $5 for the fifth.

DRIVING A RIVER TUNNEL THROUGH A MIXED FACE OF EARTH AND ROCK.

In the construction of the rapid transit tunnels under the East River at Old Slip, Manhattan, New York City, considerable difficulty was encountered near the bulkhead line, where the shield was driven through a mixed face of earth and rock. This earth for the most part was filled ground containing piling and old cribbing. The method employed in constructing the tunnel was described by Clifford M. Holland, Tunnel Engineer, in the Public Service Record, from which the following note is taken:

The method of excavation is shown in the accompanying illustration. The procedure was as follows: First operation, bottom heading excavated in rock for 125 ft. to 170 ft. in advance of shield; second operation, concrete cradle with embedded rails constructed throughout length of heading; third operation, the rock and muck immediately ahead of periphery of shield is excavated for a distance of 2 ft. 2 in.; fourth operation, the shield is shoved ahead 2 ft. 2 in. on the embedded rail by jacks operating under a 5,000-lb. per square inch hydraulic pressure; fifth operation, the core of rock and muck occupying the center portion of shield is removed; sixth operation, a ring of iron is erected, then the third, fourth, fifth and sixth operations are repeated until the shield is within about 10 ft. of advanced bottom heading when the first operation is again resumed.



Tunnel Excavation With Shield in Mixed Face of Earth and Rock.

Seventeen jacks were distributed around the periphery of the shield, their combined thrust amounting to about 2,500 tons. The cast iron rings with which the tunnel was lined were each 2 ft. 2 in. long, and consisted of plates and a key. They were put in place by means of a hydraulic erector attached to the tail of the shield. Breast boards were used to support the soft ground at the top while the rock was being drilled and blasted with light charges.

The air pressure was about 16 lb. per square inch. The maximum rate of progress in advancing the heading was 15 ft. per 24-hour day. The maximum progress in erecting the iron was 4 rings per 24-hour day.

The dynamite used was a 60 per cent gelatine, consisting of ⅞-in. sticks weighing 4 to 5 ounces per stick. For the bottom heading 50 to 90 lb. of 60 per cent gelatine dynamite were used for a complete 5-ft. advance. The drill chart is shown in the illustration. The firing data were as follows: First shot, holes (a) 4 ft. to 6 ft. deep, using about 20 sticks of dynamite; second shot, holes (b) 2½ to 4 ft. deep loaded with two sticks per hole; third shot, holes (c) drilled after (a) and (b) holes were shot, using 10 to 12 sticks to remove core.

A typical gang on the tunnel work was made up as follows:

Heading.	Cradle	Shield Operation.
2 Drill Runners	Concreted by heading gang.	3 Drill Runners.
2 Drill Runners' Hlprs		3 Drill Runner's Hlprs.
1 Heading Boss		1 Heading Boss.
8 Muckers		1 Powder Monkey.
1 Car Pusher.		1 Muck Boss.
1 Powder Monkey.		10 Muckers.
		2 Groutmen
		4 Ironmen.
		1 Hydraulic Man.
		2 Gravelmen.

THE FIRST STEAM RAILROAD APPRAISAL BY THE ILLINOIS PUBLIC UTILITIES COMMISSION.

A railway appraisal involving a number of interesting features was completed recently by the State Public Utilities Commission of Illinois. This was the first appraisal of a steam railroad property made by the Illinois Commission and its findings are of considerable interest. The important features developed are given in the January Bulletin of the Commission from which the following matter is taken:

In April, 1916, the Illinois Terminal R. R. Co., with headquarters at Alton, Ill., applied to the State Public Utilities Commission of Illinois for permission to sell its property for a certain sum to a newly-formed corporation, the Illinois Terminal Ry. Co. The latter company also requested permission to issue securities for purchasing the property and for making extensions to form a belt line around the city of East St. Louis, Ill.

The Illinois Terminal R. R. is a steam line devoted exclusively to the handling of freight, and extends from Alton, Ill., southerly and easterly, 16.5 miles, to a connection with the Toledo, St. Louis & Western R. R. at LeClaire, Ill., a short distance from Edwardsville, Ill. The road is of good construction throughout, has well ballasted track, heavy rails, and modern bridges and locomotives. The business done is of a switching and transfer character, and when the proposed extensions are constructed the road will furnish physical connections between practically all the railroads entering St. Louis from the east.

Proper disposition of the petitions necessitated a valuation of the property of the Illinois Terminal R. R. Co., the present operating corporation. The company submitted an appraisal prepared by themselves, setting forth the value of the property May 1, 1916. In addition to the value of the physical property, large amounts were included for "going value" and for value due to the possession of certain profitable contracts with industrial corporations and with other railroads. This valuation was upon a reproduction basis and certain articles, such as locomotives, were valued at present so-called "war prices," although purchased at much less. Large values were assigned certain lands and expert testimony was introduced in support of these amounts.

An independent valuation, as of Oct. 1, 1916, and constituting the first appraisal of a steam railroad property by the Illinois Commission, was prepared by H. E. Bartlett, Assistant Chief Engineer, who utilized the principles and procedure underlying the federal valuation of common carriers, now in active progress throughout the United States. The property of the company was examined with the utmost thoroughness to determine its condition from an operating standpoint, and the inventory count embraced every tie and angle bar of the railroad. After the inventory was completed the several classes of property were segregated in accordance with the primary accounts of the Interstate Commerce Commission, and to the various articles there were applied unit prices previously determined in accordance with the best available information. These unit costs were rendered the more reliable by the fact that the books and records of the railroad were available for a considerable portion of its existence. The vice president and general manager, Mr. H. H. Ferguson, who has been connected with the road since its inception, was also able to furnish much valuable information not disclosed by the company's records. While the valuation was made nominally upon the reproduction basis, it was tempered largely with the elements of original cost, so that the total amount set up in the appraisal corresponded rather closely with the original cost of the property as determined from the books of account.

While this railroad is comparatively small, the problems arising in its valuation were nearly as numerous as in the case of a transcontinental system. Many of the major questions now at issue between the carriers and the federal government came into prominence, and their determination sets precedents for the Illinois Commission. Thus, part of the grading had been done by teams and part by steam shovels, hence the fixing of proper unit prices involved as extensive a search for supporting data as if the quantities to which they were to be applied were much greater. So, too, questions of the sufficiency of the reproduction program, whether or not there be depreciation in a composite railroad property so long as the service furnished is reasonable, and others of like character, required the most careful determination.

Land values were the source of considerable controversy, involving not only unit prices, but the question as to whether certain tracts should be considered as held for the purposes of a common carrier. Large claims were made by the company, certain witnesses testifying to values as high as $3,500 an acre for right-of-way adjacent to land used for ordinary farming purposes. Further, two tracts at Alton, neither of which is now used for railroad purposes but presumably held for future development, were included in the appraisals. The company claimed these parcels to be essential to its operations and needed at the present time, but testimony showed that one tract is owned jointly with other parties, the interests being undivided. The second tract is held for future development of dock facilities upon the bank of the Mississippi River which, it was claimed, gave the land a large potential value. Plans for the utilization of these tracts were not filed in evidence.

Some of the important features developed by the proceedings in this case are:

1. The principle was reaffirmed that a property may have more than one value, depending upon the use to which it may be put. Thus, a value for a sale or purchase between a willing seller and a willing buyer may be greater or less than that in a ratemaking proceeding.

2. That depreciation exists in a composite railroad property. The average service condition of the Illinois Terminal Railroad property, exclusive of land, as shown in the Bartlett appraisal, is 91.5 per cent. This may be compared with 76.7 per cent found by the Interstate Commerce Commission for the Elgin, Joliet and Eastern Railroad.

3. Right-of-way lands were valued at approximately their original cost to the carrier, notwithstanding this amount is more than the present value of adjacent lands, though not greater than railroad might now have to pay for similar property.

4. The probable need for lands held for purposes other than those of a common carrier must be clearly set forth; otherwise the carrier may be required to dispose of them.

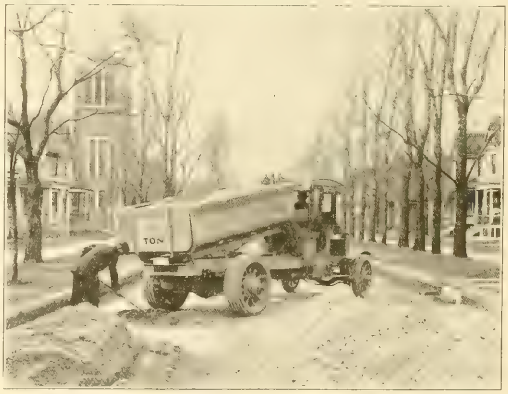
5. Values of a property should not be predicated upon an abnormal condition of the market, such as that induced by a war or other temporary cause, but should reflect the reasonable normal value of the article.

6. Values based upon the possession of favorable contracts, or similar elements, are not proper values to determine the fair present value of a property.

7. The allowance of 1.5 per cent upon the total cost of engineering, is much less than that commonly used, that is, 5 per cent, and also less than that fixed by the Interstate Commerce Commission, 4.25 per cent, for the Elgin, Joliet & Eastern R. R., an exclusively freight carrying road.

A NEW 5-TON MOTOR TRUCK.

A 5-ton truck has been added to the line manufactured by the Federal Motor Truck Co. The mechanical features of the new model, which is a larger edition of the 3½-ton Federal, include the worm drive rear axle used on all models put out by the Federal Company for the past three years, heavy motor with five-bearing crankshaft of nickel chrome steel, force feed lubrication operated at a pressure of 150 lbs., feeding all bearings, including the piston wrist pins. The cylinder block has separate heads to each cylinder, allowing the combustion chambers to be machined inside, thereby insuring even compression. An enclosed dry plate clutch, very easily operated, connects the motor with a four-speed transmission which, in turn, is connected with the rear axle worm shaft by a tubular propeller shaft with massive enclosed universal joints. Previous to adding this 5-ton model to its line of trucks, Federal officials thoroughly tested out the new truck, and it was driven thousands of miles up severe grades and over all sorts of roads that the test might be most thorough. One of the tests consisted of a trip of 1,176.6 miles, the 5-ton truck being loaded with sand, and driven from Detroit to Pittsburgh, and then brought back to Detroit over Pennsylvania, Ohio and Michigan roads. The trip to Pittsburgh was made via Toledo, Cleveland, Canton and Beaver Falls, Pa. After the tests in Pittsburgh, the truck was brought back to Detroit via Beaver Falls, Youngstown, Ohio, and Cleveland, the trip being made in five days. For the purpose of the test the chassis was provided with a steel hydraulic dump body, which filled with sand made a total load of 20,000 lb.



Federal 5-Ton Motor Truck.

METHODS AND COSTS OF CONSTRUCTING A STEEL COFFERDAM OF THE POCKET TYPE.

A steel cofferdam of the pocket type was used in the construction of Lock No. 2, Cape Fear River, N. C., for the U. S. Government. Double rows of Lackawanna sheet piling, connected at intervals by transverse rows, were driven around the lock site. The pockets thus formed were of such dimensions that when filled with earth they could resist the unbalanced pressure on the cofferdam without support. As the steel on the land side was driven well back into the river bank where the ground was level with the tops of the pockets, no filling was necessary on this side. The river pockets were filled with material dredged in the cofferdam enclosure. The following description of the methods employed in the construction of the cofferdam is taken from an article by Mr. Norman M. Chivers, Assistant Engineer, in the September-October Professional Memoirs:

The general arrangement of the cofferdam is shown in Fig. 1. The pockets were of two types. Those at the upper end had parallel inside and outside walls tied together by walings and steel cables and rods. The other pockets were without ties, the inside wall being curved to reduce distortions in the steel piling caused by the filling. Driving requirements and limited space for plant dictated the two single wall panels in the upper and lower wings. These panels were held by cables to wooden pile anchorages. Arched web piling, on account of its greater transverse strength, was used in walls held by walings and on the outside of the river pockets; straight web was used in the interior curved walls, the cross walls, and on the outside of the land pockets. The total length of the coffering was 878 ft. It required 1,871.9 tons of piling.

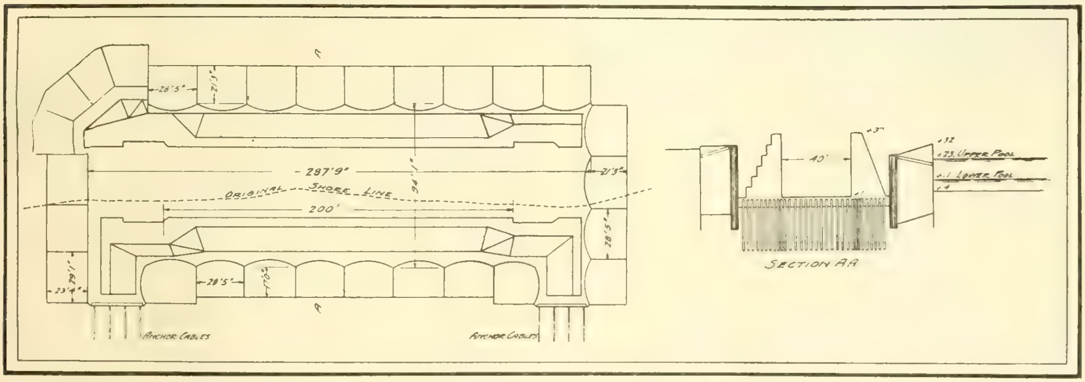


Fig. 1—Plan and Section of Cofferdam and Lock.

The cofferdam was designed to provide a protection against floods equivalent to that which experience showed to be satisfactory with the cofferdam at Lock No. 1, 33 miles farther down the river. The elevation of the top of the steel was accordingly fixed at 23.4 ft. above the mean low water obtaining at the site before the lower pool level was established by the construction of the dam at Lock No. 1. This elevation corresponded to an average height above the bottom of the river of 28 ft. The lock floor was laid before pumping out so that the coffered enclosure, after pumping out, had a depth of 31 ft.

To make the cofferdam of the height indicated and at the same time secure the necessary penetration in the sand and clay bottom of the river, piles 49 ft. long were required for the outside wall. The piles on the land side of the inside wall were of the same length, but on the river side piles 43 ft. long were used, making the inside wall 6 ft. lower than the outside. By thus sloping the tops of the pockets, the amount of filling required was reduced and dredging operations facilitated. All of the piles in the inner wall were spliced just above the elevation of the lock floor, the lower portions remaining as a part of the permanent construction.

The driving of the steel in the land cofferwall was done by two traveling pile drivers capable of movement parallel and at right angles to the center line of the lock.

The flat on which the tracks were laid was excavated out of the bank and all of the piling driven between the two outer tracks. To form the curve on the inside of the pockets a cylindrical cage moving in the ordinary driver leads and holding one of the hammers at any desired horizontal angle was provided. A similar cage, without any revolving feature, enabled the other hammer to overreach piling already partially driven for making the closure of the pockets. Piles were delivered to the drivers from the stockpiles by hand cars running on a track immediately in front of the machines. Steam for the hammers was supplied from a central boiler plant.

The two hammers used were Warrington steam hammers with striking weights of 3,000 and 1,800 lb., respectively. Each driver was equipped with two 2-in. jets, supplied by a pump installed on a scow nearby. Both pumps had a rated capacity of 250 gal. per minute at 75 lb. pressure; one with 80 lb. and the other with 125 lb. steam pressure. The jets were freely used in both land and river driving.

The penetration of the piles in the land wall varied from 39 to 48 ft. in clay, clay and sand, and marl. Considerable difficulty was experienced in driving to grade, and in several instances of absolute refusal the tops of the piles had to be cut off by the oxy-acetylene flame to permit the travelers to proceed. The smaller hammer drove an average of 9 piles per 16-hour day, and the other an average of 25.6 piles per 16-hour day.

When the land driving was completed, sufficient dredging was done at the upper and lower ends to enable the pile drivers mounted on scows to continue the coffer walls out into the river. River driving in progress is shown in Fig. 2.

The floating rig being more flexible than that used on the land, and the penetration less, varying from 18 to 21 ft., driving was faster. The smaller hammer drove an average of 17 piles per 16-hour day, and the large hammer 20.5 per 16-hour day.

The curved panels of the river wall were driven to a templet floating on the convex side of the arcs and held in place by adjustable bracing to wooden guide piles located inside the cofferdam enclosure opposite and in line with the cross walls. The bracing was so arranged that the templet could rise and fall with varying stages of the river. Alignment of the templet was secured by means of points established by triangulation on brackets nailed to the wooden piles.

The closure of all pockets was made by a large hammer. This was work which required a great deal of time and care. It was found to be very difficult to keep the piling always vertical, as a leaning tendency often developed in the direction of the driving. This lean gave trouble in closing. In four instances specially fabricated wedge-shape piles had to be used. All of the pockets were closed on the outside wall. Driving proceeded alternately on the rear and cross walls of a pocket until only the four piles nearest a corner remained. These last four piles were then entered, but not driven to grade until all were in place. Driving in succession each pile a few feet at a time completed the closure.

Diagonal steel channel walings were provided for all the cross walls, the holes for the fastening bolts in the piling being burned through with oxy-acetylene flame. The function of these walings was to prevent sliding of one interlock on another, due to the over-turning force on the backs of the pockets. In this they were only partly successful, as will be noted later.

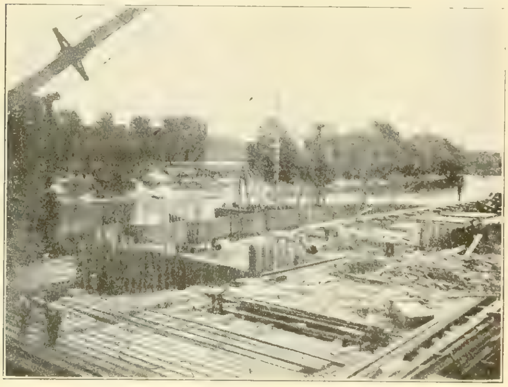


Fig. 2—Driving River Wall of Cofferdam.

A gap was left at the lower end of the cofferdam for the passage of the dredge which excavated the enclosure and the pile drivers which drove the foundation piles. The dredging was done principally by the Engineer Department Dredge Ajax, with a 5-yd. clam-shell bucket. Approximately half of the material removed, sand and clay, was used to fill the pockets at an average cost of 26½ ct. per yard. The plans required a level bottom everywhere. Considerable material immediately next to the steel could not be handled by a large clam-shell bucket, and had first to be loosened by jetting, and then taken out with a ½-yd. orange-peel bucket. Some blasting also was required in a small shelf of marl encountered in the lower wing. These operations, together with the fact that the over-depth allowance made for shoaling during pile driving proved insufficient, necessitating further dredging by siphon in those areas where piles had been driven, and by the Ajax in other places, greatly increased the cost of excavation. The total average unit cost of material removed was 46½ ct. per yard.

As dredging proceeded in front of the land wall, a serious movement of four of the pockets at the upstream end was noted, showing a tendency to turn over in the direction of the lockpit. The earth back of these pockets had not been disturbed in any way and was not surcharged. No similar movement occurred at the lower end of the wall, although here about 2,500 wooden piles were stacked immediately back of the steel. An examination of the walings on the cross walls of the leaning pockets showed that all of the fastening bolts had sheared off. As it was not found practicable to put in enough bolts to withstand the stress, it was decided to relieve partially the pressure on the back of the wall by excavation and drainage, and to tie the cross walls affected to tree anchorages by means of heavy wire cables. This proved to be a satisfactory solution of the difficulty. The maximum movement of the top of the steel amounted to 7 ft. 6 in., and no further movement was detected when the cofferdam was pumped out.

After all the foundation piles had been driven, the gap left at the lower end of the cofferdam was closed and the bottom sealed with a 5-ft. layer of concrete deposited through a tremie. This concrete was allowed a month to set before the first pump-out.

The pumping plant, located at the upper end of the cofferdam, consisted of a 12-in. Morris direct connected centrifugal designed to discharge 4,200 gal. per minute against a 30-ft. head, and a 10-in. Buffalo centrifugal, of the submerged type, designed to discharge 3,000 gal. per minute against a 32-ft. head. The 12-in. pump was mounted on pontoons inside the cofferdam, and had a discharge pipe made up of short sections to provide for increased lift as the water level fell. The 10-in. pump was rigidly attached to the wall of the cofferdam, and belt-connected to the driving engine on top of one of the pockets.

The first pump-out was purposely extended over two days in order that the coffer walls might be watched. The 12-in. pump alone was used until the pontoons grounded on the lock floor, after which the 10-in. pump completed the unwatering.

A movement of the top of the river wall toward the lock pit of 1½ in. was the only movement of the cofferdam detected during pumping operations. After the first pump-out the maximum head on the cofferdam was 26 ft. Leakage at ordinary stages of the river amounted to about 200 gal. per minute.

As the Cape Fear River is subject to rapid rises, which at times completely submerged the cofferdam, provision was made for flooding by means of a 24-in. pipe through one of the pockets at the lower end, 12 ft. below the top. Control was secured by an ordinary gate valve operated from a platform outside the cofferdam.

Unit costs of work in constructing the cofferdam are shown below:

Driving land piling, pay, supplies and repairs to plant, per pile.	$ 5.18
Driving land piling, pay, supplies and repairs to plant, per ton	5.77
Driving river piling, pay, supplies and repairs to plant, per pile.	2.28
Driving river piling, pay, supplies and repairs to plant, per ton..	2.53
Driving piling, average pay, supplies and repairs to plant, per pile	3.36
Driving piling, average pay, supplies and repairs to plant, per ton.	3.75
Splicing piles, per pile	0.47
Handling piles, per pile	0.30
Installing walings, per linear foot	0.79
Installing tie cables, each	29.45
Driving wooden anchor piles, pay, supplies and repairs to plant..	4.57

As 17.7 per cent of the total tonnage of the steel in the cofferdam was a part of the permanent construction, the costs of pile driving chargeable to the cofferdam may properly be reduced by this amount.

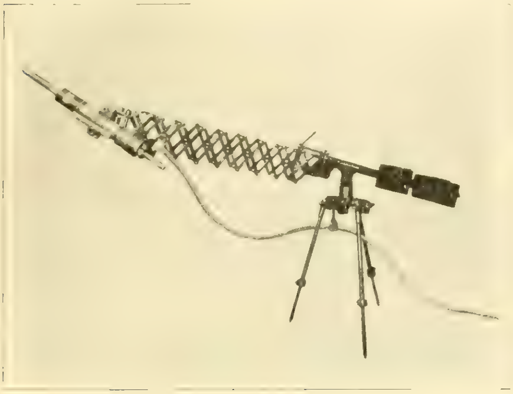
SPECIAL DUMP CARS FOR CORROSIVE MATERIAL.

A consignment of special dump cars for the handling of heavy corrosive material has been made by Orenstein-Arthur Koppel Co. of Koppel, Pa., to Marengo & Parodi at Quito, Ecuador. To resist corrosive action the bodies of these cars are built of oak heavily reinforced by galvanized bars. In other respects the cars are of the Koppel standard cradle type with round buffer frames, spring bumpers, continuous draw bars and roller bearings. The cars are constructed to dump clear of the rails and underframe thus facilitating the work and avoiding any delay.

Special Dump Car for Corrosive Material.

FLEXIBLE COUNTER BALANCED TOOL HOLDER.

A flexible counter balanced tool holder, designed to carry in suspension portable tools in their various operations, has recently been placed on the market by the Jackson, Schmitz & Shanks Engineering Co., 15 S. Desplaines St., Chicago. The appliance is claimed to be of particular service in facilitating rock drilling, pneumatic riveting, or, in fact, any operations in which portable tools have to be held to the work by one or more men.



Flexible Counter Balanced Tool Holder.

The tool holder is quickly adjusted by the workman to suit conditions. When the arm is fully extended as shown in the accompanying illustration the tool has an operating range of 16 ft. It is stated that portable tools, weighing from 20 to 150 lb. can be used to equal advantage with the standard Type "E" holder which is constructed to withstand the most severe usage above and below ground. The Type "E" holder is mounted on either tripod or truck, as standard equipment.

ROCK FROM EXCAVATION CRUSHED FOR CONCRETE.

A marked saving in the cost of the broken stone for the concrete for the power house of the Iowa Railways & Light Co. at Cedar Rapids, Ia., was secured by the contractor by the use of a portable rock crushing outfit, such as is ordinarily used in road work.

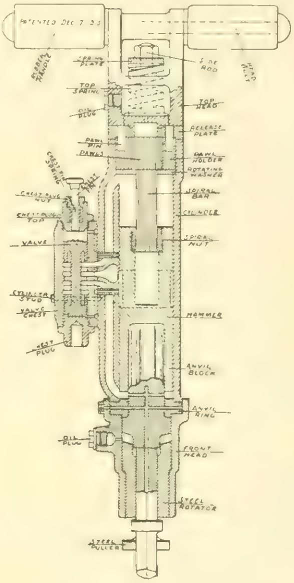
The foundation excavation, amounting to about 6,000 cu. yd., was in limestone, requiring drilling and blasting. The excavated material was loaded by derrick skips onto cars which were run out on a narrow gage track to a spoil pile. A Universal crushing plant consisting of standard portable bin, screen and crusher outfit was set up adjacent to the mixing plant. Stone is wheeled from the pile to the platform and dumped into the crusher and then carried by the conveyor to the storage bin. A saving of about 45 ct. per cubic yard over commercial prices for the crushed stone was effected. The arrangement was devised by W. De Rohan, Superintendent for R. A. Wallace, the contractor.

Crushing Plant for Preparing Concrete Material.

A SELF ROTATING HAMMER DRILL, THAT AUTOMATICALLY CLEANS THE HOLE.

A self-rotating hammer drill that is stated to automatically clean the hole, has recently been placed on the market by the Wood Drill Works of Paterson, N. J.

If by chance the air going through the steel is not enough to clean the hole, in some kinds of rock, by pressing down on the button at the top of the chest the full pressure of air is directed to the drill point cleaning the hole of all cuttings at once. By releasing the button, the drill starts automatically. One of the advantages claimed for this drill is the absence of piston breakage, and another is that no collars are required on the steels, eliminating a great deal of the blacksmith trouble and expense. The hollow piston strikes squarely on the anvil block. The steel only requires to be cut off squarely and tempered and pushed up against the anvil block of the drill.



Self-Rotating Hammer Drill.

The cylinder and chest is made of vanadium-tungsten iron. It is self-oiling, and has soft rubber grips on the handle which reduces the vibration on the operator.

BLASTING STUMPS.

It has been found that in the blasting of hardwood stumps, detonation is the best, and cheapest, done with cap and fuse; occasion but rarely arises where a blasting machine is required.

The charge is placed under the center of the stump, or the point of greatest resistance. The ability to calculate this, and the amount of charge, correctly, is obtained only by practice. It will readily be seen that correct location and amount of charge is the secret of economy.

It is best to use a bar made from a piece of steel shafting, about 5½ ft. long and weighing 23 lb. One end of this bar is drawn to a point, and the other flattened like a chisel. Use the pointed end to punch the holes for the charge, and the chisel end to cut off small roots that sometimes interfere. When a stump is to be blasted, the calculation of the amount of the charge is greatly facilitated by "sounding" it; this is done by swinging the bar endwise and striking the stump with the chisel end. It can readily be seen that, unless the stump is a solid one, it can be shaken more or less with a bar of this weight.

In blasting on heavy clay, when it is wet, the bar sometimes sticks so that it can not be used to advantage. In this case, it is better to have a 1½-in. auger, with a 4 or 5-ft. shank, with which to bore the holes.

As a rule the proper dynamite for hardwood stumps is a medium slow powder of 40 per cent strength. In old stumps on clay soil the use of dynamite of 20 per cent strength is recommended; and on lighter soil and fairly green stumps 60 per cent is better.

NEWS LETTERS.

St. Louis Items.

W. A. Gierke, Drakeville, Okla., reports his six teams idle at that point.

John Scott & Sons, St. Louis, Mo., have started on their big contract on the Santa Fe R. R.

Ed Lindsay got in on two miles of the North Texas and Santa Fe Ry. from the L. J. Smith Construction Co.

Jim Skeen died at Seneca, S. C. At the time of his death Skeen was with Hickey Bros. Co. on the Southern Ry.

W. P. McCoy has taken 11 miles of grading from the L. J. Smith Construction Co. on the North Texas and Santa Fe Ry.

C. L. Rogers has taken 5 miles of grading from the L. J. Smith Construction Co. on the new North Texas and Santa Fe Ry.

J. E. Collins has moved his outfit on 4 miles of grading on the North Texas and Santa Fe Ry. that he subbed from the L. J. Smith Construction Co.

The Ruecking Const. Co., Marine Ave. & Gasconade St., St. Louis, Mo., have a small job of steam-shovel work to let in the southern part of the city.

Robt. McCann of McCann Bros. died at Grand Tower, Ill., last week. His death was caused by scratching a pimple that turned into erysipelas and blood poison.

Contractors when in want of labor or work for their idle outfits, write Koenig Labor Agency, 612 Walnut St., St. Louis, Mo., or 503 Delaware St., Kansas City, Mo.

Z. C. Mitchell of the L. J. Smith Const. Co. is in charge of their work on the M. K. & T. R. R. Mitchell's headquarters are Tulsa, Okla., and he expects to finish this work in several weeks.

Jack Hickey of Hickey Bros., after spending the holidays with his family here, returned to Seneca, S. C. Jack reports lots of work on the Southern R. R. and turning in some big estimates at that point.

A. L. Cook of Ottawa, Kansas, has subbed 50 miles of the North Texas and Santa Fe Railway Co. (Santa Fe System) between Shattuck, Okla., and Hansford, Texas., from the L. J. Smith Construction Co.

Ground was broken at Granite City, Ill., for the new $250,000 plant of the Midland Creosote Company of Toledo, Ohio. The property will be located at Twentieth and Railroad streets and will cover about 16 acres of ground. H. M. Newton, vice-president and general manager, who has offices in the Granite City Lime and Cement building, stated that the new plant will employ 200 skilled mechanics. A report that the Midland Creosote Company was connected with the Kettle River and Quarry Company of Madison, was emphatically denied by Newton.

The P. J. Hannan Co., Boatman's Bank Bldg., St. Louis, Mo., was awarded the contract for a five-mile cut-off that the Wabash R. R. Co. is going to build near DeWitt, Mo. This cut-off being necessary on account of the Missouri River encroaching on their line near this point. The Hannan Co. is going to begin work as soon as the company decides on one of the two locations they have made. This is the heaviest piece of work that has been let in Missouri in several years. Over half of it being heavy steam-shovel work.

The L. J. Smith Construction Co., Commerce Bldg., Kansas City, Mo., has sublet all of their grading on the North Texas and Santa Fe Ry. (Santa Fe System), between Shattuck, Okla., and Hansford, Texas, with the exception of 12 miles. This 12 miles that is not covered runs about 70,000 yards to the mile. There is about 100,000 cubic yards of solid rock and 35,000 cubic yards of loose rock in this piece. The work runs through a splendid cattle and wheat country well watered by running streams and shallow wells. They expect to push this work and complete same by Nov. 1, 1917. In addition to the contract for grading 84 miles of main line this firm has also the contract for 12 miles of sidings and covers the grading, bridging, tracklaying, building of roundhouses, section houses, depots, water tanks, digging of wells, building the stock pens, fencing the right of way, in fact building the railroad complete ready to operate. Scott Mitchell, vice-president of this firm, will have direct charge of the work.

A. B. KOENIG.

PERSONALS.

Henry Welles Durham has severed his connection with Bergen County, New Jersey, and henceforth will make his headquarters at his engineering offices, 366 Fifth Ave., New York City.

The Moulton Engineering Corporation, Consulting Engineers, Portland, Me., has opened a New York office at 233 Broadway, New York City. The office will be under the direction of Mr. Horace W. Flashman, who, for a number of years has been associated with the Westinghouse Electric & Manufacturing Co. in important engineering and commercial work.

W. H. Kutz has been appointed City Engineer of Parsons, Kan. Mr. Kutz is a graduate of the School of Engineering of Kansas University. From July, 1894, to August, 1896, he was located at Parsons, Kan., with the M. K. T. Ry. Co., first as rodman and later as Resident Engineer. From September, 1896, to October, 1897, he was with Smith & Smith, U. S. Deputy Mineral Surveyors, patent and underground work. February, 1898, to December, 1898, he was at Oklahoma City, with the Frisco Ry., under Capt. J. F. Hinckley, as a division engineer. From February, 1899, to December, 1899, he was employed in the Civil Engineering Department of the Santa Fe System in charge of Masonry. From January, 1900, to April, 1900, he helped complete a resurvey of the Osage Nation for cattle leases for the Government. May, 1900, to September, 1901, he was at Denver, Colo., with the Union Pacific in charge of masonry and foundations and from September, 1901, to June, 1902, he was superintendent for the J. M. O'Rourke Construction Co. of Denver, Colo. He later was engaged in mountain location for the Colorado & Northwestern Ry. out of Boulder, and then became Chief Masonry Inspector for the Denver Union Water Works at the Chessman Dam. In 1904 he took a small earth contract on the Rock Island in Missouri. From May until Dec. 1 he was Assistant City Engineer of Oklahoma City. Last year Mr. Kutz was with the Santa Fe and the M. K. & T. in the valuation departments.

A. W. K. Billings has returned from Barcelona, Spain, where he has been for the past five years as manager of construction, managing director and vice-president of the Ebro Irrigation & Power Co., Ltd., and allied interests, in responsible charge of extensive hydroelectric construction and other work. Over 110,000 H.P. has already been developed, one interesting feature being the construction of the largest dam in Europe under very unusual conditions. Previous to his work in Spain and elsewhere for the Pearson interests Mr. Billings spent two years in Pittsburg and ten years in Cuba, principally on electric railway and power plant construction, and two years in New York as engineering manager of J. G. White & Company, Inc. He has opened an office as consulting engineer at 115 Broadway, New York City, and will devote considerable attention to work in Europe and in Latin America.

Caleb Mills Saville, recently elected President of the New England Waterworks Association, was born in Melrose, Mass. During his early years his parents moved to Medford, Mass., where his boyhood was spent. He was educated in the public schools of that city and prepared for college at Stone's School in Boston. He graduated from Harvard College in 1889 with the degree of A. B. and a cum laude in engineering.

In 1890-91 he was assistant to M. M. Tidd, civil and hydraulic engineer, of Boston, and engaged on construction work on the Simpson dry dock in Boston and on the design and construction of water works systems in various parts of the United States.

In 1891-95 he was engineer in charge of design and construction of the sewerage system in Malden, Mass. From 1895 to 1906 Mr. Saville was division engineer in the distribution department of the Metropolitan Water and Sewerage Board, having charge of numerous construction works of considerable magnitude, among which were the work incidental to building a storage reservoir at Spot Pond, the construction of the Forbes Hill Reservoir, the driving of a tunnel under the Mystic River, and much work in connection with operation and maintenance.

In 1906-07 he was hydraulic engineer with French & Bryant, of Brookline, Mass., working on studies for several water works developments. From 1907 to 1912 Mr. Saville was connected with the Panama Canal, first as assistant division engineer in charge of construction work at Gatun together with investigations for foundations and methods of construction for the Isthmian Canal Dams, and later as Engineer in charge of the 3rd Division, Office of the Chief Engineer.

Mr. Saville's investigations of the foundations of the Gatun Dam form one of the most comprehensive and profound studies of the kind which have ever been made. In his book, "The Panama Canal," Mr. F. J. Haskins states: "The engineer who worked out the details of the engineering examinations of the Gatun Dam in 1908 was Caleb M. Saville, who had had experience on some of the greatest dams in the world. Every engineer who has read Saville's report pronounces it a masterpiece of engineering investigation."

While in charge of the 3rd division of the Office of the Chief Engineer, Mr. Saville had under his direction the hydrographic and meteorological work, general surveys and special investigations. For his paper on "The Hydrology of the Panama Canal" he was awarded the Norman Medal (1914) of the American Society of Civil Engineers.

In 1912 Mr. Saville resigned his connection with the Panama Canal, having been invited by the Hartford, Conn., Water Board to become its chief engineer, to have charge of its maintenance and operation work as well as the construction of the new additional supply. This latter work consists of the building of three large dams and reservoirs, eight miles of conduit, one-half mile of rock tunnel, and an extensive filtration plant with much work of a minor character, the total cost of the additional supply expenditures being $4,000,000.

Mr. Saville has been vice-president of the New England Water Works Association for two years; is a member of the American Society of Civil Engineers, Boston Society of Civil Engineers, Connecticut Engineering Society, Harvard Engineering Society, Massachusetts Society of Mayflower Descendants, Harvard Club of Connecticut. He is the author of many articles in various engineering publications and is held to be an authority on the preparation of engineering contracts, and problems of water works management.

In October, 1891, Mr. Saville married Elizabeth Thorndike, of West Newton, Mass. They have one son, Thorndike Saville, who has received the degrees of A. B. from Harvard, B. S. from Dartmouth, C. E. from Thayer School of Civil Engineering and is now studying for the degree of Doctor of Engineering at Massachusetts Institute of Technology.

INDUSTRIAL NOTES.

The Panama Canal Division of the U. S. Government recently placed an order with the Northwestern Steel & Iron Works, Eau Claire, Wis., for four No. 610 Northwestern Mixers, of 10-ft. capacity. This is a repeat order as the Government purchased four similar mixers last May for work at Colon.

The Central Creosoting Co., 111 W. Washington St., Chicago, Ill., has purchased the business, plants and good will of the Chicago Creosoting Co. The officers of the new company are: Chairman of the Board of Directors, S. H. Bingham, president American Tar Products Co.; president, Joseph B. Card, president Indiana Zinc Creosoting Co.; vice-president, E. J. Stocking, formerly sales manager, Chicago Creosoting Co.; secretary, Wm. W. Thompson, Wm. W. Thompson & Co.; treasurer, Richard Tenwick.

The Gramm-Bernstein Motor Truck Co., Lima, O., early last year decided upon an aggressive sales campaign for domestic business instead of shipping a large proportion of their output to Europe. As a result the domestic shipments of the company for 1916 show an increase of 266 per cent over 1915. Several additions and much new equipment have been added to the plant during the past year. A new administration building and still greater additions are planned for the coming spring. The capitalization was recently increased from $500,000 to $4,000,000.

The Lakewood line of contractors' equipment, Owens-Wylie concrete chute systems, Milwaukee and Wisconsin concrete mixers and street pavers will be sold under one sales management by the Lakewood Engineering Co., Cleveland, O. The new plan contemplates the development of an organization capable of building and marketing a really complete line of contractors' equipment. Following is the personnel of the new organization: Chas. F. Lang, President Lakewood Engineering Co.; N. F. Teschan, President Milwaukee Concrete Mixer Co.; Roy G. Owens, Manager Contractors' Equipment Dept.; Lloyd Brown, Manager Car Dept.; W. A. Meddick, Assistant Manager Car Dept.; H. Walter Sykes, Manager Electrical Industrial Equipment; W. G. Grail, Manager Clam Shell Bucket Dept.; V. Truelson, Chief Engineer, Milwaukee Plant; Jas. Lockhart, Chief Engineer, Car Dept., Cleveland; Thos. D. Maley, Chief Engineer, Contractors' Equipment, Cleveland; Henry T. Pleines, General Supt., Cleveland.

Buildings and Structural Issue
of
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Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

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Volume XLVII. CHICAGO, ILL., JANUARY 24, 1917. Number 4.

THE NEW METHOD OF PAGING THE ISSUES OF THIS PERIODICAL.

Beginning in January the four special monthly issues of this periodical will hereafter be paged separately. Thus, in this Buildings and Structural Monthly issue, it will be seen that the pages are numbered at the bottom, so that if the 12 copies of this monthly issue are bound separately the page numbers will be continuous.

It is necessary, of course, to retain the numbers at the top of each page, for the use of those who take "E. & C." as a weekly and bind all copies together.

Following the index for 1916 we shall so design future indexes that they will serve both the subscribers who bind the monthlies separately and those who bind the magazine as a weekly.

THE ENGINEERING STAFFS OF MANUFACTURERS AND WHAT THEY DO.

"Publicity engineering" is a term that was coined about a dozen years ago by an engineer who specialized in advertising machinery and supplies used by engineers and contractors. At first sight it may seem to most engineers that it involves an inordinate stretching of the term engineering to embrace advertising, but consideration of the fundamental functions both of the engineer and the advertiser is apt to change one's first impression.

Within the last decade it has become increasingly the practice of manufacturers to employ engineers not only to assist in publicity campaigns but to ascertain the most economic application of their products and to find new applications. Notable among manufacturers who have done this on a large scale are companies that make Portland cement. In this connection we may also mention the work of the Hydrated Lime Bureau, under the management of Mr. Norman G. Hough, Pittsburgh, Pa. This bureau is supported by the National Lime Manufacturers' Association, and through its engineering department it not only investigates the use of hydrated lime for waterproofing concrete, but gives free advice to engineers and contractors as to the proper use of "hydrate." Similar in purpose is the engineering department of the Truss-Con Laboratories of Detroit.

Perhaps it was natural that the structural field should be the first to evolve this type of engineering organization to assist manufacturers in the wider distribution of their products, because many structural engineers had become very familiar with the products of manufacturers of this class. Hence, such engineers were eminently qualified to instruct other engineers and contractors. Consider, for a moment, the development of reinforced concrete. Here the structural engineer was himself the pioneer. Starting with E. L. Ransome and his twisted bar, we find a long line of engineers who not only designed the reinforcement itself but its economic methods of application. What more natural than that such engineers should write, or assist in writing, catalogs as well as articles descriptive of reinforced concrete?

Publicity for and instruction in the economic use of manufactured products are important functions of the engineering staffs of manufacturers, but the work of such staffs seldom ceases there. Many an engineer is today engaged in experiment and research planned to improve manufactured products, and to decrease production costs.

Although the foregoing states only what is already known to many engineers, a restatement of the facts is desirable, for at least two reasons: First, because all engineers are not fully alive to the variety and amount of valuable technical information to be found in catalogs and pamphlets issued by many manufacturers. Second, because there is a growing demand for engineering services in the publicity departments of large manufacturers of products used by engineers or contractors.

Even a small manufacturer can frequently employ an engineer to advantage, at least for part of his time, and we suggest that many an engineer could find profitable occupation in such capacity were he to seek the work with all the wit and vigor that he can muster.

GIVE US FEWER ARCHITECTURAL MONUMENTS AND MORE ENGINEERING STRUCTURES FOR PUBLIC BUILDINGS.

The average architect delights in designing a tomb when he is commissioned to provide a city hall. Look at the massive, half-windowed creations that most American cities boast about when they speak of their public buildings. There they squat, huge masses of masonry, copied after the super-surface catecombs that the Romans and Greeks erected for temples, fit spots to worship in, but ill designed as places to work in. Isn't it about time that engineers in general, and structural engineers in particular, attempt to influence public opinion away from the precedents that architects have established?

Nearly every public building that a city owns is primarily an office building. Why, then, should the design of such public buildings differ materially from the designs of commercial office buildings? Must the public have architectural monuments? Then let the monuments be built as monuments and not as hybrid office-tombs.

As we conceive it, most municipalities and all states are in greater need of the advice of engineers than of architects when it comes to the designing of public buildings. Perhaps when we have a national society of structural engineers we shall see an organized effort to educate the public to the view just expressed.

"IT MARKS THE ENTRANCE OF THE ENGINEER INTO GOVERNMENT AFFAIRS."

Last autumn when the Committee on Industrial Preparedness was finished, Thomas A. Edison said to Howard E. Coffin, head of the committee:

> The committee's [illegible] program is in effect already an accomplished fact. With this accomplishment comes not merely a better understanding between the business men of America and their government, but [illegible] most dramatically the entrance of the trained non-partisan engineer, doing his job as the sole basis of efficiency, integrity and Americanism into the affairs of the government.

While it would be easy to take issue with the statement that the work of this committee of engineers marks the entrance of non-partisan engineers into the affairs of government, it is a fact that the publicity given to the work of Mr. Coffin and his associates, has served to awaken many business men to the fact that engineers are more than designers of machines and structures. Apparently even Mr. Edison had not previously thought of the engineer as a factor in governmental management.

One of the lessons to be drawn from the work of the Committee on Industrial Preparedness is this: Let engineers lose no opportunity to assume leadership in matters of public concern, and the public will soon come to regard engineers as leaders. Leadership gravitates to the strong man who seizes every opportunity to lead.

Let engineers study political economy, write and talk on political economy, and lose no chance to thrust themselves forward as political leaders graduated from the school of engineering efficiency.

THE COST OF AN ARCHITECT'S DESIGN COMPARED WITH THAT OF A STRUCTURAL ENGINEER.

It is not often that a building designed by an architect is redesigned by a structural engineer. Recently, however, Mr. Louis Mulhausen, structural engineer, of Philadelphia, redesigned the structural part of a two-story commercial building in Wilmington, Del., with a resultant decrease in cost of nearly 8 per cent. The following table of costs is based on the actual sub-bids received on the two designs as given in Engineering News:

	Architect's design.	Engineer's design.
Permit, bonds, insurance, shoring, pumping foreman and watchman, miscellaneous expenses, etc.	$ 2,996	$ 2,985
Lumber	1,507	987
Millwork	2,500	2,500
Carpenter labor	3,095	2,595
Demolition, excavation and stone masonry	2,854	2,854
Brickwork	5,337	4,337
Cut stone	331	331
Ornamental terra cotta work	1,858	1,858
Structural steel	4,759	....
Reinforced concrete and cement	2,600	6,569
Ornamental iron	874	874
Dahlstrom door	288	288
Ash hoist	165	165
Stair work (wood)	185	185
Tile	192	192
Weather stripping	63	63
Roofing and sheet metal	317	317
Plastering	2,998	3,100
Hardware	618	618
Painting and glazing	984	984
	$34,521	$31.802

It will be noted that the engineer did not alter the architectural effect. What he did do was to substitute reinforced concrete columns and floors for steel columns and girders with wood floor and joists. He also substituted metal lath for wood lath. Thus he produced a thoroughly fireproof building at less cost than one that was not fireproof. The walls were 12x8-in. hollow tile with stucco finish outside.

The building was 45x65 ft. for two floors and roof, with a 16x60-ft. wing for one floor and roof, making a total of 10,695 sq. ft. of floors and roof. The cost was $3.23 per sq. ft. for the architect's design, and $2.97 for the engineer's design.

INTEGRAL WATERPROOFING OF CONCRETE AND STUCCO.

The voids in ordinary concrete invite water and the resulting change in volume of the concrete often leads to its disintegration. This is particularly noticeable in thin concrete slabs and in stucco exposed to moisture. It has been frequently urged that the best waterproofing is an excess of cement, but this claim is open to question, for even neat cement mortar is quite porous.

In "Structural Conservation" for September-October, Mr. R. Alfred Plumb discusses "Integral Waterproofing as a Necessary Factor of Ignorance in Waterproofed Concrete." He maintains that, although it is frequently urged that by scientific grading of the aggregate the voids in concrete can be reduced to a minimum, it remains a fact that in practice such ideal results are never secured throughout any considerable mass of concrete. Hence, the part of wisdom is to use an integral waterproofing—waterproofing introduced during mixing of the concrete—in order to provide a factor of safety against poor workmanship and failure to attain an ideal "mix" of graded aggregates. This reasoning is sound. We use factors of safety in applying strength data, and there is fully as great need of factors of safety in securing waterproofness in concrete.

In the November-December issue of the same magazine some interesting facts are given about "China wood oil" for waterproofing. It is stated that linseed oil is saponified by the alkali (calcium hydroxide) in concrete, and that consequently ordinary paints do not make a durable dampproof coating on concrete; whereas suitably prepared "China wood oil" is alkali proof. The Chinese have long used this oil in treating the hulls of boats. The oil is extracted from the nuts of the tung tree. This tree has been grown successfully in America, and it is estimated that 120,000 acres of these trees would be required even now to meet the present American demand for "China wood oil."

EDITORIAL COMMENT.

Electric motors for operating concrete mixers, hoists, etc., are certain to be used more extensively by contractors, particularly in city work. One contractor, for example, uses a 15-h.p. Westinghouse motor on a half-yard mixer that turns out 80 cu. yd. per 8-hour day. It should be remembered that it is hard to beat a price of 5 ct. per kilowatt-hour for small quantities of power; and that this price, or better, is usually obtainable from electric companies.

The great war is accountable for many records, none of which is more remarkable than the building of an 8-story (100x400 ft.) reinforced concrete frame for a factory, having 360,000 sq. ft. floor area, in 41 days, 16 of which it was impossible to work on account of rain and Sundays. In the 25 days of actual work, 20,000 cu. yd. of concrete were placed, 5,000 being in the footings and 15,000 in the columns and Akme girderless floors. The carpenters, of whom there were 300, worked three 8-hour shifts daily. Forms were ⅞-in. tongue-and-groove, and 4x4's, of which 1,000,000 ft. B. M. were used. Forms for four floors and one set of columns were provided. A description of this form work will be found elsewhere in this issue. The laborers worked two shifts daily, one 10-hour, one 12-hour. About 1,000 men of all classes were engaged on the work. The contractors were the F. W. Mark Construction Co. The building is owned by the Baldwin Locomotive Works and was designed by the Condron Co. of Chicago.

There are about 20,000 bridge and structural iron workers in America, 70 per cent of whom belong to the International Association of Bridge & Structural Iron Workers' Union. Their average working hours are 44 per week, and their wages range from $5 to $16 a day. Only one apprentice is allowed for every seven mechanics, the wages of apprentices being $2.50 to $4. The duration of apprenticeship is 1.5 to 5 years. Might it not pay many a young structural engineer to become an apprentice structural worker for a couple of years? He would have ample leisure in which to study his profession after his 8-hour day's open-air work was done, and his close acquaintance with his fellow workmen would give him a better insight into human nature and the problems of management.

The Engineering Association of the South has decided to discontinue its existence, the members having decided that there is no place for a sectional society, one that is neither broadly national nor purely local. The Nashville section of the society, with 150 members, will become the Nashville Engineering Association, and other sections may follow this plan of evolving into local societies.

The Lehigh Portland Cement Co. now owns 15 plants that form a chain from the Atlantic to the Pacific Ocean. The company is capitalized at $18,000,000. This company typifies the modern tendency to consolidate manufacturing plants in different parts of the country under one ownership and management.

METHOD OF ERECTING LARGE CONCRETE ARCH BRIDGE WITHOUT FALSEWORK.

In the construction of a new bridge over the Susquehanna River at Harrisburg, Pa., for the Cumberland Valley R. R., all risk of falsework for center supports being carried away by floods was eliminated by the use of steel brackets.

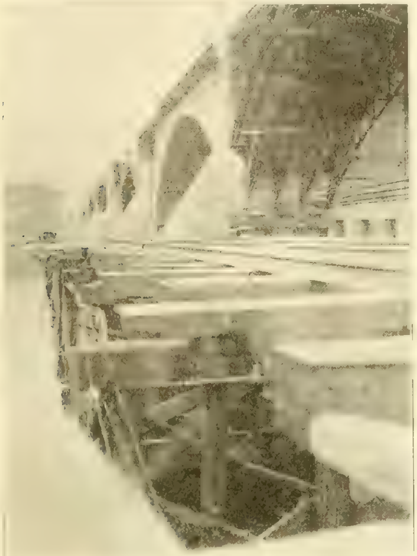

Fig. 1—Service Trestle and Bracket.

The bridge consisted of 45 arches and was nearly a mile in length. In order not to interfere with the railroad traffic the bridge was built in two longitudinal halves, so that in building the structure 90 arches were constructed.

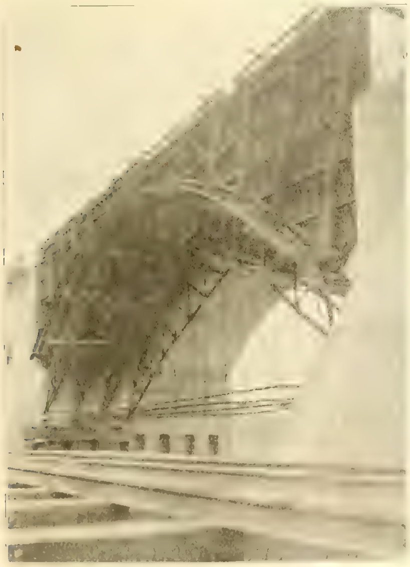

Fig. 2—Bracket in Position and Centers.

The center supports were made up of standard structural steel shapes, of plates and angles. They were 6 ft. high, 3 ft. wide at the top and tapered to 1 ft. at the base, were built in pairs and fastened together at the top with a 12-in. steel channel and at the base with a 6-in. angle, and crossed braced with a 1-in. turnbuckle rods. Four sets of these supports were used to each center.

In building the piers, provision was made for supporting these center supports. Four openings, 1 ft. 6 in. wide, 1 ft. deep and 6 ft. high, were made in the face of each pier. Six bolts were concreted in these openings, when the piers were built, to be used to fasten the brackets. The openings were built at the proper elevation to receive the centers, and above the highest flood stage of which there was any record. Ten sets of center supports were used on the work, each set weighing about 2 tons. A McMyler locomotive crane was used in setting the brackets, and they were quickly removed from one position to another in this manner.

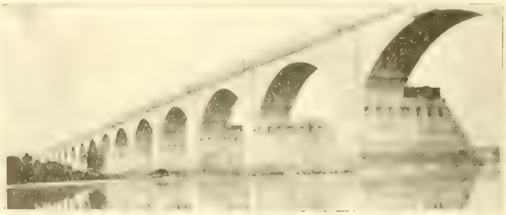

Fig. 3—Completed Half of Bridge.

The wisdom of using these center supports was demonstrated a number of times during the construction of the bridge, as several floods occurred that had sufficient force to have carried away any false work that might have been in the river at the time.

On June 18 the most severe and unexpected flood occurred, carrying away the entire service trestle and bending the 18-in. steel I-beams used in the floor of the trestle, like the letter U around the upstream end of the new piers.

The use of these center supports also eliminated beyond doubt any danger of settlement to the concrete arches before the final act had taken place. Considerable time was also saved by this method. The steel brackets also had a high salvage value upon completion of the work. Figures 1 and 2 show the brackets in position with centers. Figure 3 is a view of the completed half of the bridge in the east channel of the river. F. P. Kemon was the superintendent for the contractor.

Proposed New Hudson River Bridge.—A bill is before the New York legislature authorizing the Hudson River Connecting R. R. Corporation, New York Central Ry., to construct within five years from May 1, 1918, a bridge, for railroad purposes only, across the Hudson River between Castleton, N. Y., and Schodack Landing, having a clearance of not less than 135 ft. above mean level of the Hudson River, with a single span across the river, with no piers or abutments between the dykes. The proposed legislation repeals original authority in Act of April 28, 1913, which specified that spans of such bridge, between upper Schodack Island and Shad Island, should be not less than 300 ft. between piers, and that bridge be completed within five years from May 1, 1914. The spans as originally proposed limited the width of navigable channel to 400 ft. As revised by the railroad company provision is made for a westerly span of 600 ft. and an easterly span of 400 ft. The present width of navigable channel at this point is 400 ft. The revised plans permit widening the channel 200 ft., also for an additional channel 400 ft. wide to be dredged by the railroad company.

The annual meeting of the Illinois Society of Engineers, will be held January 25 and 26 in the rooms of the Western Society of Engineers, Monadnock Block, Chicago, Ill.

ACTION OF SEA WATER ON CONCRETE SPECIMENS AT BOSTON NAVY YARD.[*]

This paper describes a test of 24 concrete specimens which were immersed in sea water for 7 years. The object of the tests was to determine the action of sea water on concrete specimens of wet and dry consistencies, of various proportions of ingredients, and of different brands of cement, as well as the effect of special compositions.

The specimens were examined at intervals of about one year, and record was made of their condition. The results of these observations have been tabulated, and show progressive deterioration of some of the specimens and remarkable durability of others. Recently, the specimens were examined with great care, and graded in the order of durability.

The results are interesting, and seem to show, briefly:

(a) That the 1:1:2 mixture is superior to the 1:2½:4½, and that the 1:2½:4½ is, in turn, superior to the 1:3:6;
(b) That the wet mixtures are superior to the dry.
(c) That the effects of magnesia or alumina in varying proportions are not very marked, and follow no apparent law, although the two most durable specimens are those lowest in alumina content;
(d) That extra care in mixing produced decidedly beneficial results;
(e) That hydrated lime was of no benefit, but rather a detriment;
(f) That the addition of Sylvester wash was harmful; and
(g) That the addition of clay to the cement had a slightly beneficial result.

The deterioration occurred between high- and low water, and was most marked at mid-tide. Above high water there was little deterioration, and the same is true, but to a less marked extent, of the concrete continually submerged.

The experiments are not sufficiently extensive to warrant drawing final conclusions in all cases, unless confirmatory evidence is available.

Each of the 24 specimens is 16 ft. long and 16 in. square, weighing from 4,050 to 4,350 lb. They are hung on Pier 9, at the Boston Navy Yard, in such a manner that the lower ends are continually immersed, the upper ends but barely immersed, and the center portions are subject to alternate action of the air and salt water due to the 10-ft. tides.

The specimens were originally suspended, in February, 1909, from the old Pier 9, but, as this was rebuilt, they were moved on Dec. 5, 1911, to Pier 8, east side. Later, it became necessary to renew the supporting bridles, and, on Sept. 19 and 20, 1912, the specimens were removed and leaned against the quay wall and on Oct. 30 and 31, 1912, were moved to the newly constructed Pier 9. The piers are of open wooden pile construction, giving the sea water a free flow. About April, 1914, a pipe line for furnishing oil to naval vessels was placed on Pier 9, and since then the concrete has become coated with a thin film of fuel oil. The sea water is that of Boston Harbor.

Table I shows the scheme of the tests. For the purpose of this report, they have been arranged in 11 series, according to the cement used. Those in series II to XI, inclusive, in every case have parallel tests in Series I, which is the principal one.

The progressive condition of the specimens is shown in Table II, where the information is collated for convenient reference.

A very careful examination, by three experienced observers, was made in April, 1914, at low tide, of all the specimens, and they were graded and classified on the spot in accordance with their condition at the time. The estimates of grade and class were on the basis of durability or serviceability of the concrete, as if it were in actual service. The examination was made after the specimens had been in the water 5 years, since which time there have been no changes of note. The various classes, especially the upper ones, grade into one another with definite, but without particularly strong, dividing lines. The specimens in each class are arranged from left to right in the order of durability.

The following is a copy of the report on classifying and grading the specimens:

Specimens graded largely as to condition at point of maximum deterioration.

Specimens in order of durability.

Elevation of tide, 1 ft. above mean low water at time of examination.

Class 1: Perfect condition; No. 14.

Class 2: Nearly perfect condition; Nos. 3, 16.

Class 3: Very fine condition, but with slight deterioration; Nos. 18, 12, 10, 2.

Class 4: Very good condition, but with some deterioration; Nos. 6, 5.

Class 5: Good condition, but with deterioration apparent; Nos. 15, 20, 24, 17, 1.

Class 6: Fair condition; deterioration apparent; concrete soft in spots near low-water mark; Nos. 9, 11, 13.

Class 7: Poor condition; decided deterioration; concrete shows deterioration at low water; Nos. 4, 8.

Class 8: Very bad condition; concrete disintegrated and badly eroded above low water; Nos. 22, 19, 23.

Class 9: Exceedingly bad condition; concrete totally disintegrated and eroded above low water line, No. 7.

The following specimens showed deterioration between the 1914 and 1916 inspections, arranged in the order of

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[*] Abstract of a paper by R. E. Bakenhus in December, 1916, Proceedings of the American Society of Civil Engineers, Vol. XLII, No 10, pp. 1571-1601.

TABLE I—SCHEME OF TESTS.

Proportions.	Series I Mixed Cement. Average Alumina. Al_2O_3 7.21% MgO 2.74%		Series II Blanc Cement. Al_2O_3 8.22% MgO 1.11%		Series III Atlas Cement. Al_2O_3 8.5 % MgO 2.58%		Series IV Helderberg and Lehigh Cement. Al_2O_3 5.61% MgO 2.51%		Series V Hermmoor Erz Iron Ore Cement. Al_2O_3 0.94% MgO 0.43%		Series VI Universal Slag Cement. Al_2O_3 8.04% MgO 1.63%		Series VII like Series I, Concrete extra well mixed. Al_2O_3 7.21% MgO 2.74%		Series VIII like Series I, using sea water.		Series IX like Series I, with lime		Series X. like Series I, with Sylvester Solution		Series XI like Series I, with 5% clay		
	No. of Specimen	Water, in pounds per cubic foot	No.	Water	No.	Water	No.	Water	No.	Water	No.	Water	No.	Water	No.	Water	No.	Wat'r	No.	Wat'r	No.	Wat'r	
1:1 :2	1	Dry 9.3																					
1:1 :2	2	Wet 10.4	10	Wet 10.2	12	Wet 11.0	14	Wet 11.7	16	Wet 11.1	18	Wet 11.8											Series XII
1:1 :2	3	Very wet 12.5																					
1:2½:4½	4	Very dry 5.9																					
1:2½:4½	5	Wet 7.1																					
1:2½:4½	6	Very wet 12.2																					
1:3 :6	7	Very dry 5.8																					
1:3 :6	8	Wet 7.7																					
1:3 :6	9	Very wet 11.3	11	Very wet 12.1	13	Very wet 11.3	15	Very wet 11.7	17	Very wet 10.2	19	Very wet 13.03	20	Very wet 9.7	21	Very wet 9.7	22	Very wet 10.7	23	Very wet 9.6	24	Very wet 9.5	Series XIII

Note—The weight of water, in pounds per cubic foot, takes no account of moisture in the ingredients before mixing.

greatest deterioration: Nos. 22, 19, 23, 7, 11, 4. The remaining specimens show no noticeable deterioration between 1914 and 1916. It is to be noted that all those that have deteriorated are in the lowest classes as to durability. Careful consideration showed that the classification made in 1914 need not be changed.

All specimens since 1914 have become coated with a fine layer of crude fuel oil between extreme high and low waters. This coating hides many of the minor defects in the specimens. The oil comes from the outlets placed on Pier 9 for fueling naval vessels.

TABLE II—PROGRESSIVE CONDITION OF SPECIMENS.

Feb., 1909. Specimen No.	March, 1910.	March, 1911.	June, 1912.	November, 1912.	December, 1913.	April, 1914.	January, 1916.
1	Face rough.	Face rough, 1 in. deep.	Face rough 1 in. deep.	Face eroded 1 in. deep.	Face badly eroded.	Face badly eroded; porous spots.	Face badly eroded; some porous spots.
2	No action.	No action.	No action.	Slightly rough face; slightly porous.	Faces slightly pock-marked.	Edges slightly soft; faces practically perfect.	Edges slightly soft; faces practically perfect.
3	No action.	No action.	Sunken.	Slightly rough face; scale on back.	Face and back slightly pock-marked.	All faces very good; surface slightly pitted; slight injury to edges.	Faces very good; surface slightly pitted. Slight injury to edges.
4	Face pitted 1 in., sides less.	Face pitted, 1 in., sides less.	Sunken.	Very rough face; concrete porous.	Face badly eaten; back flaked, sides rough.	Face badly eroded; little pitting and erosion.	Face badly eroded; some pitting and erosion.
5	No action.	No action.	No action.	Face slightly rough; porous spots on back.	Faces (all) pock-marked.	Some erosion on face; pitting on one side.	Some erosion on face; pitting on one side.
6	Very good. Surface soft.	No action.	No action.	Edges slightly broken.	Fine condition. Corners worn; face marked.	Edges show action. Face pitted; soft spots on back.	Edges show action. Face pitted; soft spots on back.
7	Face pitted; sides less.	Face eroded; sides good.	Considerable erosion, front and back.	Badly eroded; back and face; corners soft and crumbling.	Very poor; concrete soft and crumbling.	Very poor condition, 2½ in. in length completely gone.	Very poor condition; 5 ft. in length completely gone.
8	No action.	No action except back eroded.	Back eroded 4 in.; concrete soft.	Back disintegrated. Sides and face rough. Concrete soft.	Front and sides marked. Back 5-in. hole.	Face and sides slightly pitted. Back eroded 4 in. deep.	Face and sides slightly pitted. Back eroded 5 in. deep; rods exposed.
9	No action.	No action.	No action except back chafed.	Edges worn Slghtly rough face.	Face marked Edges worn.	Face badly pitted; sides and back slightly pitted.	Face badly pitted; side and back slightly pitted.
10	No action.	No action.	No action.	Slightly rough face.	Face marked.	Some erosion on face; side and back slight pitting.	Some erosion on face; sides and back slight pitting.
11	No action.	No action.	No action.	Slightly rough face.	Face and sides marked.	Concrete hard, but chalky on surface. Edges soft. Face and sides very good.	Concrete chalky on surface. Edges soft. Face and sides good.
12	Very fair. Small areas on face have action noticeable.	No action except slight roughness on face.	No action except back slightly peeled.	Slightly rough face. Porous spots on back.	Back and face very slightly marked.	Very slight pitting on back; other faces fine.	Slight pitting on back; other faces fine.
13	Very slight action on face	No action except slight roughness on face.	No action except slight erosion on back.	Slight disintegration of face.	Face marked; edge worn 2 in. deep.	Face pitted entire length; edges soft. Back slight pitting.	Face pitted entire length; edges soft. Back slight pitting.
14	No action.	No action.	No action.	No action.	No action.	No action.	No action.
15	Fair; slight action on front.	No action except slightly rough on face.	Back slightly flaked.	Slight deterioration, face and side.	Faces slightly marked.	Concrete slightly soft in spots. Face and sides pitted; slight erosion.	Concrete soft in spots. Face and sides pitted; slight erosion.
16	No action.	No action.	No action.	No action.	No action.	Very slight pitting at extreme low water.	Very slight pitting at extreme low water.
17	No action.	No action.	All sides flaked.	All sides flaked.	All sides very slightly flaked.	All sides pitted. Front badly pitted at M. L. W.	All sides pitted. Front badly pitted at M. L. W.
18	No action.	No action.	No action.	No action.	No action.	Sides perfect. Front and back slight pitting.	Sides perfect. Front and back pitted.
19	Very good. Face slightly rough.	No action except slightly rough on face; cracked.	Face eroded; concrete soft.	Back disintegrated; concrete very soft.	Badly flaked; concrete crumbling back 4-in. hole.	Face badly pitted; concrete soft; back eroded 4 in. deep.	Concrete soft and spongy; face pitted; sides badly eroded.
20	Very good. Face slightly rough.	No action except slightly rough on face; cracked.	No action except back flaked.	Slight deterioration at M. L. W.	Flaking all sides; corners worn.	Concrete fairly hard. Face eroded. Sides and back somewhat pitted.	Concrete fairly hard. Face eroded. Sides and back somewhat pitted.
21	Very good. Face slightly rough.	No action except slightly rough on face. cracked.	Sunken.	Lost.	Lost.	Lost.	Lost.
22	Good; crack on face.	Rough on face.	Face and back eroded.	Face and sides eroded; edges broken.	Badly marked; 4-in. hole on face; concrete soft and dead.	Face eroded 6 in. over space 3 ft. Sides and back pitted. Concrete soft.	Face eroded 7 in., length 4 ft. Sides and back eroded from 1 to 3 ft. Concrete soft.
23	Cracked. Corners broken.	Cracked. Corners broken.	Face and back edges eroded.	Edges badly broken away.	Face badly flaked; edges bad.	Concrete eroded from 4 to 8 in. at M. L. W. Soft.	Concrete eroded from 5 to 8 in. deep about M. L. W. Concrete soft below M. L. W.
24	Good. Face slightly soft.	No action.	No action except edges eroded.	Back edges worn; mortar on face deteriorated.	Face slightly marked. Edges worn.	Faces and sides pitted. Edges slightly soft on lower half Spec. Concrete fairly hard.	Faces and sides pitted. Edges slightly soft on lower half. Concrete hard.

Contracts for rapid transit construction work in New York City aggregating more than $24,000,000, were awarded during 1916 by the Public Service Commission. In all 81 of the 87 sections of the Dual System are now under contract, leaving only six main contracts yet to be awarded. The total amount of contracts already let is more than $196,000,000 upon lines to be owned by the city of New York. Upwards of 17,000 men are employed on rapid transit work.

CONCRETE PILE TRESTLE BRIDGE WITH CELLULAR SLABS.

The State Highway Commission of Minnesota is preparing plans for concrete pile trestle bridges for this season's construction that it is believed can be built with a saving of from 25 to 45 per cent under the cost of the present types. The advantages of this type of structure were described by Mr. C. E. Nagel, Deputy State Engineer, in a paper presented before the recent Northwestern Road Congress. An abstract of Mr. Nagel's paper follows:

The economical length of span figures about 20 ft. center to center of bents carried by 3 piles per bent each driven to a bearing of 20 tons. Should it be determined, after one pile has been driven, that a 20-ton bearing is not obtained with the length of pile provided, four or even five piles can be driven per bent where necessary to give the required support.

A concrete cap is cast embedding the tops of the piles and serving to carry the ends of the spans. No abutments are used and the bridge is made long enough to provide sufficient waterway after allowing the fill at each end to run through the end bent on a 1 to 1 slope with a riprap protection.

For the superstructure the Minnesota Highway Commission has designed a cellular slab bridge, in which type the under side is cored out by means of corrugated arch forms resulting in a saving of one-third the volume of concrete that would be used in a solid slab.

In the spans 20 ft. over all in length, the metal forms are semi-circular in shape with a radius of 1 ft. and the beams formed between them are 13 in. wide at the bottom. There are also cross beams at the middle of the span and at the quarter points. The concrete is 4 in. thick at the crown of the arch, making a total depth of beam of 16 in. A half size model of a superstructure of this type was tested out as part of the Minnesota Highway Commission exhibit at the State Fair and proved very satisfactory.

Concrete pile trestle bridges can be built, using a multiple number of spans of a standard length, making it possible to make economical use of metal forms and metal falsework used repeatedly with no need for intermediate wood piles, which are so essential for falsework under present conditions. This fact, taken together with the absence of cofferdam work for piers and abutments, makes it possible to construct this type of bridge even when the water level is above normal, or when freshets are likely to occur, so that the working season will be lengthened considerably.

Where a longer span is necessary, it can be supported on a double row of concrete piles with a large concrete cap and the approach spans built with concrete pile trestles. This type of structure used for the entire bridge or used for the approaches makes it possible to conveniently lengthen the bridge at any time this proves necessary, such as in the cases where new drainage projects increase the volume of water to be carried, as there are no end abutments to be replaced by piers before additional spans can be added.

Concrete pile structures, of course, are not suitable to locations where rock or extra solid foundations exist, but in those cases the excavation work is not expensive. With sand foundations and in swampy locations, the present cofferdam excavations are very expensive and it is in situations of this nature that the greatest economy will result.

For driving concrete piles more machinery and less hand labor is necessary than for constructing ordinary substructures, which is a decided advantage with the present unsatisfactory labor conditions and the labor that is employed will necessarily be higher paid and more reliable. Much less time will be necessary to construct these bridges as the excavation work will be eliminated and the standard sets of forms and falsework can be put in place ready for concrete in a shorter time than for present types of concrete bridges. This will cause less inconvenience to traffic which is either detoured or carried over a temporary bridge with the approaches barely passable.

The grade elevation of most bridges is determined by highwater elevation and by using a combination of short spans which have the least depth, the floor of the bridge can be placed a minimum distance above highwater elevation, resulting in less height of approach fills.

In the past there has been a continued increase in width of roadway and there is likely to be a demand for still greater widths on main trunk lines as traffic increases in volume and concrete girder bridges cannot be widened, but the type above referred to can conveniently have the hand rail and curb removed and an additional width added. One of the biggest advantages is that protection will be obtained against the lowering of the bed of the stream for drainage projects.

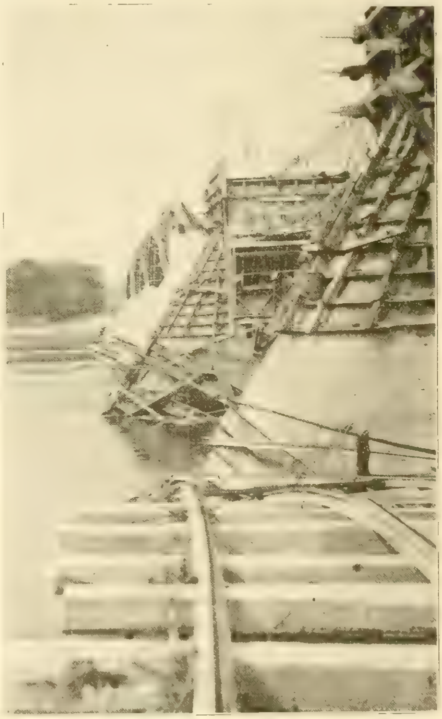
The total expenditures for road improvements in the New England states in 1914 was $15,435,766. This is an increase over road expenditures in 1904 of over $7,000,000.

STRAIGHTENING BENT I-BEAMS BY HANGING OVER FIRE.

A large number of badly bent 15-in. I-beams were successfully straightened on the job at Harrisburg, Pa., by F. P. Kemon, superintendent for the contractor engaged in building the Cumberland Valley R. R. bridge over the Susquehanna River.

The trestle in which the beams were employed was about 2,200 ft. long and extended entirely across the east channel of the river. The river bed is scoured bare and the framed trestle bents rested directly on the rock. The entire trestle, which was upstream from the new bridge, was carried out by a severe and unexpected flood on June 18, practically all of the stringers being bent around the ends of the piers.

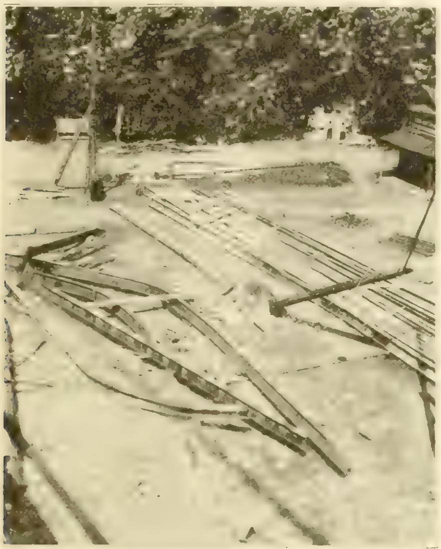
As soon as the water receded sufficiently the stringers were recovered by a locomotive crane, and removed to an island. The work of straightening them on the island proceeded so rapidly that it was possible to rebuild the entire trestle and start concreting at one end of bridge in less than six weeks after the flood. Aside from the present high price of steel it is doubtful if a sufficient number of stringers to replace the bent ones could have been delivered to the job within this time.



Wrecked Trestle Showing I-Beams Bent Around Piers.

The method used to straighten the beams was as follows: Two gin poles were erected with three guys each, one to right and left side of pole and one directly in rear. In this way there were no guys directly over the fire. The gin poles leaned toward each other and were 80 ft. apart. Some 60-lb. rail was blocked up on stone midway between the gin poles to form a grate for the fire; scrap lumber was used as fuel. Wire rope and steel blocks were used as main falls from top of gin poles. These falls were made fast to each end of the 72-ft. I-beams. The beams were suspended with the bent side down when the wood fires were started, so as to straighten of their own weight. It was found necessary to guy them sideways with No. 9 gage wire to keep the web as nearly as possible in a horizontal position, and to prevent the beams from falling too fast as the heat increased.

The work was very successful. Considerable loss would have resulted, both in time and money, had not this method been resorted to as the great length of the beams and their badly bent condition would not have permitted their being returned to a mill to be rerolled; they would have had to be cut up and scraped.



Bent I-Beams and Method of Straightening Them.

STANDARD DEPRECIATION RATES FOR FACTORY BUILDINGS AND EQUIPMENT.

The depreciation standards in the accompanying tabulation were adopted last February at a meeting at Chicago of manufacturers of conveyors and elevators, held to draw up an agreement on some standard form of accounting procedure:

	Per cent on cost	Per cent on reducing value
Buildings and accessories		
Reinforced concrete or steel and tile	2	3
Brick and steel with non-combustible roof and concrete floor	[illegible]	[illegible]
Brick, steel and wood	[illegible]	[illegible]
Brick and wood	[illegible]	[illegible]
Steel frame, wooden roof and corrugated iron walls	[illegible]	[illegible]
Steel frame, non-combustible roof and corrugated iron walls	[illegible]	[illegible]
Concrete block, with wooden roofs and floors	3.5	8
All wood structures, well built (20 years)	4.5	10
All wood structures, cheap (20 years)	5	12
Sprinkler system (20 years)	4	7.5
Heating and ventilating system (20 years)	4	7.5
Water and sewer piping and sanitary fixtures (where separate)	[illegible]	[illegible]
Tanks and reservoirs, steel	[illegible]	[illegible]
Tanks and reservoirs, wood (10 years)	[illegible]	[illegible]
Machinery and large equipment:		
Boilers, pumps, feed-water heaters and air compressors	[illegible]	[illegible]
Power piping	[illegible]	[illegible]
Switchboards, wiring and conduit	[illegible]	[illegible]
Engines and dynamos	5	10
Machinery, motors, machine tools, traveling cranes, etc.	[illegible]	[illegible]
Punch presses, bending rolls, power shears and drop hammers	[illegible]	[illegible]
Shafting, pulleys, hangers and belting	50	
Machine tool accessories, boring bars, [illegible] key-seating broaches, etc.	50	
(All renewals to repairs.)		
Cupolas, converters, melting furnaces and accessories	[illegible]	[illegible]
Annealing and heating furnaces, ovens, [illegible] etc.	5	10
Motor trucks	[illegible]	[illegible]
Storage-battery locomotives (battery renewals to repairs)	[illegible]	[illegible]
Horses and wagons	12	35
Small tools:		
For machines, net additions	50	
Hand tools, net additions	50	
Punches and dies:		
(Standards) net additions	[illegible]	
Chills, iron and steel flasks and accessories:		
Net additions	[illegible]	
Fixtures, furniture and miscellaneous equipment:		
1. Steel shelving, lockers, etc.	[illegible]	[illegible]
2. Mechanical appliances, net additions	60	
3. Department wiring and electric fixtures, net additions	[illegible]	
4. Miscellaneous items (wood), net additions	70	

METHOD OF ERECTING RADIO TOWERS.

During the last two or three years the Bureau of Yards and Docks of the Navy Department has erected numerous radio towers for its wireless telegraph systems. In 1914-15 400-ft. high towers were installed at the naval training station, Great Lakes, Ill. In 1915-16 300-ft. high towers were erected at Point Isabel, Texas. All of these were of triangular section. The work at Great Lakes and at Point Isabel was in charge of A. C. Cunningham, Civil Engineer, U. S. Navy. In the January issue Public Works of the Navy, Mr. Cunningham describes the erection methods.

The first tower at Great Lakes was started with interior false work composed of four sections of the tower which were later used at a higher elevation of the tower when their location was reached. The object of the false work was to brace the unsupported legs of the tower until they could be joined by the horizontal girders and bracing. This false work was found to be of little use. The legs of the tower were placed in position with a gin pole and supported with guys. The connecting girders were hoisted to position with gin pole and connected to the legs. The guys to legs of tower gave complete control for movements in making connections.

The erection of the upper sections was done with a short derrick having long guys leading to the ground. The derrick was mounted on a platform on the section last placed and used to hoist and place the materials of the section under construction. The short derrick was continuously moved up as the erection progressed.

In erecting the second tower at Great Lakes no false work was used and the entire section was done with a gin pole. The proceeding in erecting the legs was the same as with the first tower. The gin pole was then rigged with three tackles at the bottom and three about midway of its length. This permitted of hoisting the gin pole upward through the center of the tower and giving it an inclination in any direction desired. With the gin pole the erection of the second tower at Great Lakes was accomplished with much more convenience and in a much shorter time.

The contractor for the towers at Point Isabel on being informed of the gin pole method used in erecting the towers at Great Lakes decided to use it. The erection proved entirely convenient and economical and was accomplished in a short time.

From these two experiences it would seem that the gin pole method for erecting radio towers is the most convenient, economical, and requires the least time. The pole can be kept under perfect control with the tackles and its position is quickly and easily shifted. Both poles under consideration were set in sockets in which they could be rotated, and the one at Point Isabel was fitted with sheaves instead of having hoisting blocks lashed on.

The towers at Great Lakes and at Point Isabel were of triangular cross section. While the triangular design may admit of some economy of material, Mr. Cunningham thinks that a square section would provide an easier design, both for shopwork and erection. A rectangular construction is the most familiar to shop workmen and erection foremen. There is less chance of error in laying out and fabricating the material, and more allowance for adjustment in erection. Bevels cannot be avoided in designing radio towers on account of their taper, but where the section is square the bevels are in one plane only, and this is a condition with which shops are familiar.

A marked difference in the field connections between the towers at Great Lakes and at Point Isabel was in the method of fastening. The connections at Great Lakes were made with machine-turned bolts of a driving fit, and at Point Isabel with rivets. There was no difficulty with the bolts at Great Lakes. The sections were assembled and reamed, one after the other, in the shop before being shipped out, and came together quite perfectly in erection. In consequence the bolts drove snugly and gave a full bearing. In erecting the first tower at Great Lakes the joints were first made with assembling bolts and then followed up with the machined bolt. In erecting the second tower the joints were made with the machine bolt at once. The latter method is preferable, as it saves the shifting of the bolts and prevents any possibility of the holes getting out of line.

As a matter of general principle, riveting is to be preferred to bolting. In the case of radio towers there are special considerations. There is only a small amount of riveting done at any one level, and it is done under inconvenient conditions. A considerable shifting of rivet-heating forges and air piping for pneumatic riveters is required, and the greater the altitude the more inconvenient this becomes. Riveting may be delayed or prevented by weather conditions that would not affect the placing of machined bolts.

From the experience with the erection of the towers at these two stations Mr. Cunningham is of the opinion:

First—That a tower of square cross section would permit of the most rigid and convenient erection.

Second—That the entire gin pole method is the most rapid, convenient and safe.

Third—That machined bolts and reamed connecting holes provide for the most rapid erection and the most certain results.

DESIGN FEATURES FOR CONCRETE AND REINFORCED CONCRETE CONSTRUCTION.*

Lengths of Beams and Columns.—The span length for beams and slabs simply supported should be taken as the distance from center to center of supports, but need not be taken to exceed the clear span plus the depth of beam or slab. For continuous or restrained beams built monolithically into supports, the span length may be taken as the clear distance between faces of supports. Brackets should not be considered as reducing the clear span in the sense here intended, except that when brackets which make an angle of 45° or more with the axis of a restrained beam are built monolithically with the beam, the span may be measured from the section where the combined depth of beam and bracket is at least one-third more than the depth of the beam. Maximum negative moments are to be considered as existing at the end of the span as here defined.

When the depth of a restrained beam is greater at its ends than at mid-span and the slope of the bottom of the beam at its ends makes an angle of not more than 15° with the direction of the axis of the beam at mid-span, the span length may be measured from face to face of supports.

T-Beams.—In beam and slab construction an effective bond should be provided at the junction of the beam and slab. When the principal slab reinforcement is parallel to the beam, transverse reinforcement should be used, extending over the beam and well into the slab.

The slab may be considered an integral part of the beam, when adequate bond and shearing resistance between slab and width of beam is provided, but its effective width shall be determined by the following rules:

(a) It shall not exceed one-fourth of the span length of the beam;

(b) Its overhanging width on either side of the web shall not exceed 6 times the thickness of the slab.

Beams in which the T-form is used only for the purpose of providing additional compression area of concrete should preferably have a width of flange not more than 3 times the width of the stem and a thickness of flange not less than one-third of the depth of the beam. Both in this form and in the beam and slab form the web stresses and the limitations in placing and spacing the longitudinal reinforcement will probably be controlling factors in design.

Floor-Slabs Supported Along Four Sides.—Floor-slabs having the supports extending along the four sides should be designed and reinforced as continuous over the supports. If the length of the slab exceeds 1½ times its width, the entire load should be carried by transverse reinforcement.

For uniformly distributed loads on square slabs, one-half the live and dead load may be used in the calculations of moment to be resisted in each direction. For oblong slabs, the length of which is not greater than 1½ times their width, the moment to be resisted by the transverse reinforcement may be found by using a proportion of the live and dead load equal to that given by the formula, $r = \frac{l}{b} - 0.5$, where l = length and b = breadth of slab. The longitudinal reinforcement should then be proportioned to carry the remainder of the load.

In placing the reinforcement in such slabs account may well be taken of the fact that the bending moment is greater near the center of the slab than near the edges. For this purpose two-thirds of the previously calculated moments may be assumed as carried by the center half of the slab and one-third by the outside quarters.

Loads carried to beams by slabs which are reinforced in two directions will not be uniformly distributed to the supporting beams, and the distribution will depend on the relative stiffness of the slab and the supporting beams. The distribution which may be expected ordinarily is a variation of the load in the beam in accordance with the ordinates of a parabola, having its vertex at the middle of the span. For any given design, the probable distribution should be ascertained and the moments in the beam calculated accordingly.

Continuous Beams and Slabs.—In computing the positive and negative moments in beams and slabs continuous over several supports, due to uniformly distributed loads, the following rules are recommended:

(a) For floor-slabs the bending moments at center and at support should be taken at $\frac{wl^2}{12}$ for both dead and live loads, where w represents the load per linear unit and l the span length.

(b) For beams, the bending moment at center and at support for interior spans should be taken at $\frac{wl^2}{12}$ and for end spans it should be taken at $\frac{wl^2}{10}$ for center and interior support, for both dead and live loads.

(c) In the case of beams and slabs continuous for two spans only, with their ends restrained, the bending moments both at the central support and near the middle of the span should be taken as $\frac{wl^2}{10}$.

(d) At the ends of continuous beams, the amount of negative moment which will be developed in the beam will depend on the condition of restraint or fixedness, and this will depend on the form of construction used. In the ordinary cases a moment of $\frac{wl^2}{16}$ may be taken; for small beams running into heavy columns this should be increased, but not to exceed $\frac{wl^2}{12}$.

Flat Slab.

The recommendations in the following paragraphs relate to flat slabs extending over several rows of panels in each direction. Necessarily the treatment is more or less empirical. The coefficients and moments given relate to uniformity distributed loads.

Column Capital.—For computation purposes, the diameter of the column capital will be considered to be measured where its vertical thickness is at least 1½ in., provided the slope of the capital below this point nowhere makes an angle with the vertical of more than 45°. In case a cap is placed above the column capital, the part of this cap within a cone made by extending the lines of the column capital upward at the slope of 45° to the bottom of the slab or dropped panel may be considered as part of the column capital in determining the diameter for design purposes. Without attempting to limit the size of the column capital for special cases, it is recommended that the diameter of the column capital (or its dimension parallel to the edge of the panel) generally be made not less than one-fifth of the dimension of the panel from center to center of adjacent columns. A diameter equal to 0.225 of the panel length has been used quite widely and acceptably.

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*From the final report of the Special Committee on Concrete and Reinforced Concrete submitted Jan. 17 at the annual meeting of the American Society of Civil Engineers and printed in the Proceedings of the Society, Vol. XLII, No. 10, pp. 1657-1703.

Dropped Panel.—Generally, it is recommended that the width of the dropped panel be at least 4/10 of the corresponding side of the panel as measured from center to center of columns, and that the offset in thickness be not more than 5/10 of the thickness of the slab outside the dropped panel.

Slab Thickness.—The following formulas for minimum thicknesses are recommended as general rules of design when the diameter of the column capital is not less than 1/5 of the dimension of the panel from center to center of adjacent columns, the larger dimension being used in the case of oblong panels. For notation, let

t = total thickness of slab, in inches;
L = panel length, in feet;
w = sum of live load and dead load, in pounds per square foot.

Then, for a slab without dropped panels,

$$\text{minimum } t = 0.024\, L \sqrt{w} + 1\tfrac{1}{2};$$

for a slab with dropped panels,

$$\text{minimum } t = 0.02\, L \sqrt{w} + 1;$$

for a dropped panel whose width is 4/10 of the panel length,

$$\text{minimum } t = 0.03\, L \sqrt{w} + 1\tfrac{1}{2}.$$

In no case should the slab thickness be made less than 6 in., nor should the thickness of a floor-slab be made less than 1/32 of the panel length, nor the thickness of a roof slab less than 1/40 of the panel length.

Bending and Resisting Moments in Slabs.—Analysis shows that, for a uniformly distributed load, and round columns, and square panels, the numerical sum of the positive moment and the negative moment at a vertical section of a slab taken across a panel along a line midway between columns, and another section taken along an edge of the panel parallel to the first section, but skirting the part of the periphery of the column capitals at the two corners of the panels, is given quite closely by the equation

$$M_x = \frac{1}{8} wl \left(l - \frac{2}{3} c\right)^2.$$

In this formula and in those which follow relating to oblong panels,

w = Sum of the live and dead loads per unit of area;
l = Side of a square panel measured from center to center of columns;
l_1 = One side of the oblong panel measured from center to center of columns;
l_2 = Other side of oblong panel measured in the same way;
c = Diameter of the column capital;
M_x = Numerical sum of positive moment and negative moment in one direction.
M_y = Numerical sum of positive moment and negative moment in the other direction.

For oblong panels, the equation for the numerical sum of the positive moment and the negative moment at the two sections named becomes

$$M_x = \frac{1}{8} wl_2 \left(l_1 - \frac{2}{3} c\right)^2$$

$$M_y = \frac{1}{8} wl_1 \left(l_2 - \frac{2}{3} c\right)^2$$

where M_x is the numerical sum of the positive moment and the negative moment for the sections parallel to the dimension, l_2, and M_y is the numerical sum of the positive moment and the negative moment for the sections parallel to the dimension, l_1.

What proportion of the total resistance exists as positive moment and what as negative moment is not readily determined. The amount of the positive moment and that of the negative moment may be expected to vary somewhat with the design of the slab. It seems proper, however, to make the division of total resisting moment in the ratio of 3/8 for the positive moment to 5/8 for the negative moment.

With reference to variations in stress along the sections, it is evident from conditions of flexure that the resisting moment is not distributed uniformly along either the section of positive moment or that of negative moment. As the law of the distribution is not known definitely, it will be necessary to make an empirical apportionment along the sections; and it will be considered sufficiently accurate generally to divide the sections into two parts and to use an average value over each part of the panel section.

Positive Moment.—For a square interior panel, it is recommended that the positive moment for a section in the middle of a panel extending across its width be taken as

$$\frac{1}{25} wl \left(l - \frac{2}{3} c\right)^2.$$

Of this moment, at least 25 per cent should be provided for in the inner section; in the two outer sections of the panel at least 55 per cent of the specified moment should be provided for in slabs not having dropped panels and at least 60 per cent in slabs having dropped panels, except that in calculations to determine necessary thickness of slab away from the dropped panel at least 70 per cent of the positive moment should be considered as acting in the two outer sections.

Negative Moment.—For a square interior panel, it is recommended that the negative moment for a section which follows a panel edge from column capital to column capital and which includes the quarter peripheries of the edges of the two column capitals (the section altogether forming the projected width of the panel) be taken as

$$\frac{1}{15} wl \left(l - \frac{2}{3} c\right)^2$$

Of this negative moment, at least 20 per cent should be provided for in the mid-section and at least 65 per cent in the two column-head sections of the panel, except that in slabs having dropped panels at least 80 of the specified negative moment should be provided for in the two column-head sections of the panel.

Moments for Oblong Panels.—When the length of a panel does not exceed the breadth by more than 5 per cent computation may be made on the basis of a square panel with sides equal to the mean of the length and the breadth.

When the long side of an interior oblong panel exceeds the short side by more than one-twentieth and by not more than one-third of the short side, it is recommended that the positive moment be taken as

$$\frac{1}{25} wl_2 \left(l_1 - \frac{2}{3} c\right)^2$$

on a section parallel to the dimension, l_2; and

$$\frac{1}{25} wl_1 \left(l_2 - \frac{2}{3} c\right)^2$$

on a section parallel to the dimension, l_1; and that the negative moment be taken as

$$\frac{1}{15} wl_2 \left(l_1 - \frac{2}{3} c\right)^2$$

on a section at the edge of the panel corresponding to the dimension, l_2, and

$$\frac{1}{15} wl_1 \left(l_2 - \frac{2}{3} c\right)^2$$

at a section in the other direction. The limitations of the apportionment of moment between inner section and outer section and between mid-section and column-head sections may be the same as for square panels.

Wall Panels.—The coefficient of negative moment at the first row of columns away from the wall should be increased 20 per cent over that required for interior panels, and likewise the coefficient of positive moment at the section half way to the wall should be increased by 20 per cent. If girders are not provided along the wall, or the slab does not project as a cantilever beyond the column line, the reinforcement parallel to the wall for the negative moment in the column-head section and for the positive moment in the outer section should be increased by 20 per cent. If the wall is carried by the slab, this concentrated load should be provided for in the design of the slab. The coefficient of negative moments at the wall to take bending in the direction perpendicular to the wall line may be determined by the conditions of restraint and fixedness as found from the relative stiffness of columns and slab, but in no case should it be taken as less than one-half of that for interior panels.

Reinforcement.—For a column-head section, reinforcing bars parallel to the straight portion of the section do not contribute to the negative resisting moment for the column-head section in question. In the case of four-way reinforcement, the sectional area of the diagonal bars multiplied by the sine of the angle between the diagonal of the panel and the straight portion of the section under consideration may be taken to act as reinforcement in a rectangular direction.

Arrangement of Reinforcement.—All bars in rectangular bands or diagonal bands should extend on each side of a section of maximum moment, either positive or negative, to points at least 20 diameters beyond the point of inflection, as defined herein, or be hooked or anchored at the point of inflection. In addition to this provision, bars in diagonal bands used as reinforcement for negative moment should extend on each side of a line drawn through the column center at right angles to the direction of the band at least a distance equal to 35/100 of the panel length, and bars in diagonal bands used as reinforcement for positive moment should extend on each side of a diagonal through the center of the panel at least a distance equal to 35/100 of the panel length; and no splice by lapping should be permitted at or near regions of maximum stress, except as just described. Continuity of reinforcing bars is considered to have advantages, and it is recommended that not more than one-third of the reinforcing bars in any direction be made of a length less than the distance center to center of columns in that direction. Continuous bars should not all be bent up at the same point of their length, but the zone in which this bending occurs should extend on each side of the assumed point of inflection, and should cover a width of at least 1/15 of the panel length. Mere draping of the bars should not be permitted. In four-way reinforcement, the position of the bars in both diagonal and rectangular directions may be considered in determining whether the width of zone of bending is sufficient.

Reinforcement at Construction Joints.—It is recommended that at construction joints extra reinforcing bars equal in section to 20 per cent of the amount necessary to meet the requirements for moments at the section where the joint is made be added to the reinforcement, these bars to extend not less than 50 diameters beyond the joint on each side.

Provision for Diagonal Tension and Shear.—In calculations for the shearing stress which is to be used as the means of measuring the resistance to diagonal tension stress, it is recommended that the total vertical shear on two column-head sections constituting a width equal to one-half the lateral dimension of the panel, for use in the formula for determining critical shearing stresses, be considered to be one-fourth of the total dead and live loads on a panel for a slab of uniform thickness, and to be three-tenths of the sum of the dead and live loads on a panel for a slab with dropped panels. The calculation of what is commonly called punching shear may be made on the assumption of a uniform distribution over the section of the slab around the periphery of the column capital and also of a uniform distribution over the section of the slab around the periphery of the dropped panel, using in each case an amount of vertical shear greater by 25 per cent than the total vertical shear on the section under consideration.

Bending Moments in Columns.—Provision should be made in both wall columns and interior columns for the bending moment which will be developed by unequally loaded panels, eccentric loading or uneven spacing of columns. The amount of moment to be taken by a column will depend upon the relative stiffness of columns and slab, and computations may be made by rational methods, such as the principle of least work, or of slope and deflection. Generally, the larger part of the unequalized negative moment will be transmitted to the columns, and the column should be designed to resist this bending moment. Especial attention should be given to wall columns and corner columns.

TABLE FOR COMPUTING QUANTITIES OF CEMENT AND AGGREGATE FOR ONE CUBIC YARD OF CONCRETE.

Contributed by E. Earl Glass.

The accompanying table is an extension of Fuller's Rule. The quantity, X, or the number of barrels of cement as computed from the table, will be found to check within 0.01 bbl. of the figures given in Taylor & Thompson's tables.

Let c = parts of cement.
s = parts of sand.
r = parts of rock or gravel.
S = sum of parts = c + s + r, as 1:2:4 mix, S = 7.
C, t, and y are constants taken from table below.
T_s = tons of sand per cu. yd. of concrete.
T_r = tons of rock per cu. yd. of concrete.
Y_s = cu. yd. of sand per cu. yd. of concrete.
Y_r = cu. yd. of rock per cu. yd. of concrete.
X = bbl. of cement per cu. yd. of concrete.

Then $X = \frac{C}{S}$; $T_s = Xts$; $T_r = Xtr$; $Y_s = Xys$; $Y_r = Xyr$.

Values of C:

Proportion of voids in broken stone or gravel.	Volume of barrel of cement assumed		
	3.5 cu. ft.	3.8 cu. ft.	4.0 cu. ft.
50%	12.1	11.4	11.0
45%	11.8	11.1	10.6
40%	11.2	10.5	10.1
30%	10.4	9.74	9.30
20%	9.65	9.02	8.6
t	0.175	0.19	0.20
y	0.13	0.141	0.148

The value of t is based on an assumed weight of sand, rock, gravel of 100 lb. per cubic foot.

Example: Given a 1:2½:5½ mix, 40 per cent voids in the rock, and 3.8 cu. ft. per bbl. of cement.

1:2½:5 = 9 = S
C = 10.5

$\frac{10.5}{9}$ = 1.17 bbl. of cement per cu. yd. concrete.

1.17 × 0.19 × 2½ = 0.555 tons of sand.
1.17 × 0.141 × 2½ = 0.412 cu. yd. of sand.
1.17 × 0.19 × 5½ = 1.22 tons of rock.
1.17 × 0.141 × 5½ = 0.91 cu. yd. of rock.

The department of Plant and Structures of New York City, maintains and supervises 42 bridges, representing an outlay of city funds of $120,738,354. The estimated cost of these structures is $78,864,379. The estimated cost of land acquired for bridge construction and approaches is $41,873,975.

DESIGN OF FORMWORK AN IMPORTANT FACTOR IN BREAKING OF SPEED RECORDS IN FLAT SLAB CONSTRUCTION.

Contributed by Albert M. Wolf

A simple and very economical layout of formwork was, in addition to the simplicity of the structural design, one of the main factors responsible for the extraordinary speed attained in the erection of the building recently completed for the Baldwin Locomotive Works at Hamilton and 18th Sts., Philadelphia, Pa. The structure, an 8-story flat slab building 396 ft. 8 in. x 98 ft. 6 in. in plan, has story heights of 12 ft. 6 in. with exposed exterior concrete columns and floor slabs and low brick spandrel walls between columns supporting the steel sash windows which form 60 per cent of the exposure. The floors are of the Akme System 2-way reinforced flat slab type with panels 20 ft. wide the long way of the building and 16 ft. 6 in. for the center bay transversely and 20 ft. 6 in. for the two outer ones on each side. The slabs are supported on circular interior columns having 45° flaring heads 4 ft. 6 in. in diameter at the top, surmounted by a depressed plate 8 ft. square and 6 in. thick with edge beveled back 6 in. from their intersection with the underside of slab. The exterior columns are rectangular with a flaring head on the inner side only.

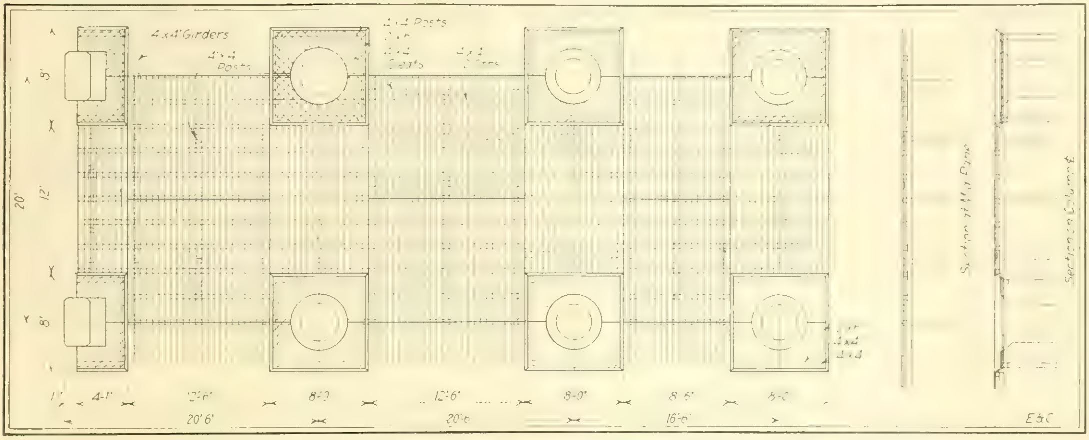


Fig. 1—Plan and Section of Formwork for the Building for Baldwin Locomotive Works.

The formwork was materially simplified at the outset by the use of only two sizes of lumber; ⅞-in. tongue and groove and 4x4-in. material, with the exception of some 2x6-in. planking used in the exterior column forms. Owing to the rapidity of constructing four complete sets of slab forms were not removed until the concrete was about two weeks old. One set of column and head forms sufficed since these were removed in 24 hours after pouring, if necessary.

From Fig. 1, a detail drawing of the typical formwork, it can be seen that the forms for the depressed plates and the main decking were built up in units; this was done to facilitate handling, placing and removal without the usual loss of lumber due to breakage when form boards are loosely laid on the centering. The depressed plate forms were built in halves and consisted of two layers of ⅞-in. lumber laid on the diagonal with a sufficient number of battens to keep them in shape. These units were the first to be erected and were placed on a 4-post tower consisting of 4x4-in. posts carrying 4x4-in. crosspieces at the top in one direction and 2x6-in. in the other. The tower was braced by horizontal braces near bottom and diagonals placed in A-frame fashion to stiffen the horizontal members at the top.

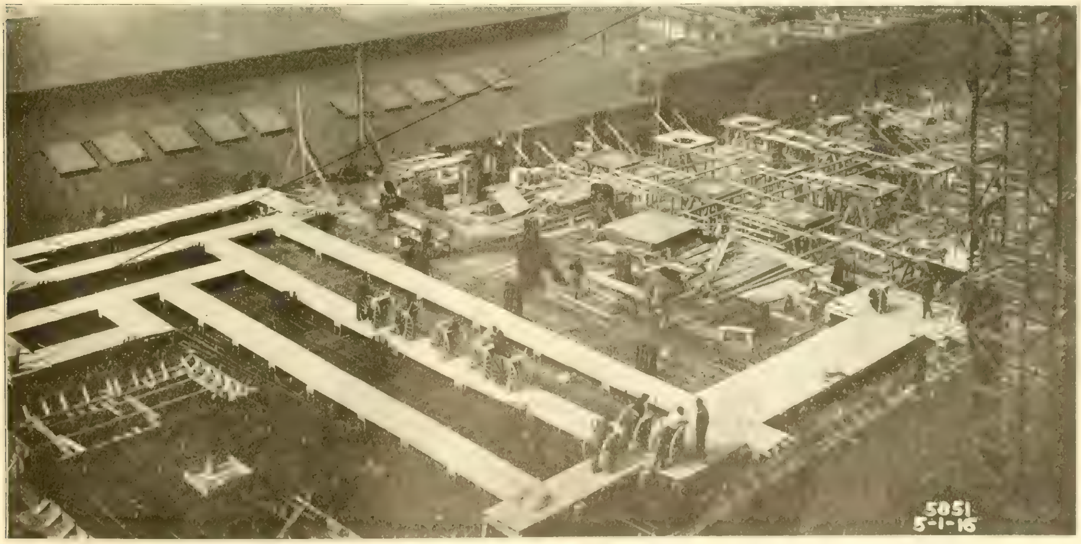


Fig. 2—View of Partially Completed Forms for the Philadelphia Building of the Baldwin Locomotive Works.

After several panels of depressed plate forms and centering were placed, the erection of centers for floor form was begun. As shown in Fig. I the centering consisted of a line of posts on column center lines (longitudinal) and three intermediate, spaced about 5 ft. centers supporting 4x4-in. girders extending the length of the building. The 4x4-in. joists spaced about 2 ft. centers were placed transversely on the girders and upon these the floor form units consisting of ⅞-in. tongue and groove lumber fastened together by three lines of ⅞-in. cleats. These units were built so that one unit 8 ft. wide and 12 ft. long fitted in between the depressed plates (longitudinally) and two units each 10 ft. long, and 12 ft. 6 in. wide for outside panels and 8 ft. 6 in. wide for center panel, in the remaining space. This made the handling of forms very simple and economical and reduced the breakage to a minimum. A view of partially completed forms is shown in Fig. 2.

The building was designed by the Condron Co., Industrial and Structural Engineers of Chicago, and erected by the F. W. Mark Construction Co. of Philadelphia and Cleveland.

LOADING TEST OF GYPSUM COMPOSITION FLOOR BY U. S. BUREAU OF STANDARDS.

Tests were conducted last November by the U. S. Bureau of Standards on a Metropolitan composition floor. The report of the test is given in the January issue of "Public Works of the Navy" and is reprinted below in full:

Description of Test Floor.

Design of Metropolitan Floor.—The design of this type of floor is based primarily upon the employment of steel cables placed in tension in the form of a series of suspension members. These suspension strands are so placed between I-beam supports that when a superimposed load is placed on the floor surface the resultant stress is transmitted through the tension of the cables to the I-beams on each side of the floor panel. The composition of calcined gypsum and wood chips which forms the body of the floor is intended to be used in direct compression merely to transmit the superimposed load uniformly to the steel cables.

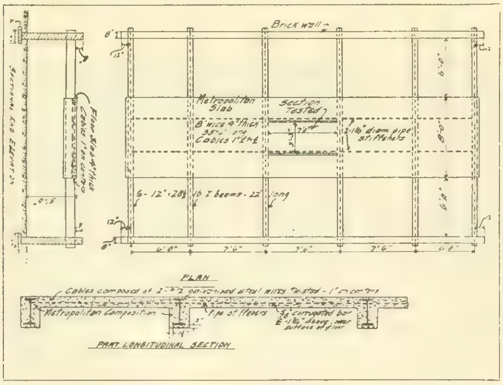

Brick wall
Metropolitan Slab
Section Tested
8' wide 4" thick
Cables 1" ctrs
2-1¼" diam pipe stiffeners
6-12".28½ lb I beams-22' long
Sectional End Elevation
Floor Slab 4" thick Cable 1" on centre
6'-0"
7'-6"
7'-6"
7'-6"
6'-0"
PLAN
Cables composed of 2-#12 galvanized steel wires twisted - 1" centers
Metropolitan Composition
Pipe stiffeners
PART LONGITUDINAL SECTION

Fig. 1—Loading Test Metropolitan Composition Floor.

Construction.—The test floor was constructed Oct. 20, 1916 (warm day, partly cloudy, mean temperature 72° F.), according to details shown in Fig. 1, which details were followed closely. As shown in the cut, the structure consisted of five spans of Metropolitan composition floor, 8 ft. wide, supported by six 12-in., 28½-lb. I-beams, which beams rested in two 8-in. brick walls, placed 20 ft. between inside faces. The floor was constructed only 8 ft. wide, in order to permit of lateral observations of the behavior of the floor under the test loading.

The floor as constructed differed from the customary type of Metropolitan floor construction, in that there were placed in each panel two 1¼-in. diameter iron pipes 7 ft. 5 in. long at the one-third points of the 8-ft. floor section, parallel with the cables, normal to the webs of the I-beams, and on top of the transverse ⅝-in. rod. These pipes were installed to give stiffness to the I-beams, in order to counteract any overturning effect produced by the pull of the cables on the top flanges of the I-beams. The builders' statement was to the effect that in the customary type of construction these pipes are not used, since the floor, being continuous for the full distance between the brick walls, gives the necessary stiffening or strut action.

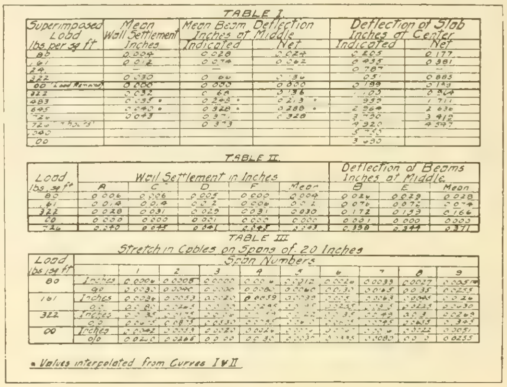


TABLE I.

Superimposed Load lbs per sq ft	Mean Wall Settlement Inches	Mean Beam Deflection Inches at Middle		Deflection of Slab Inches at Center	
		Indicated	Net	Indicated	Net
80	0.004	0.028	0.024	0.205	0.177
161	0.012	0.074	0.062	0.435	0.381
241	—	—	—	0.787	—
322	0.030	0.166	0.136	[illegible]	0.885
00 Load Removed	0.000	0.000	0.000	0.199	0.189
322	0.032	0.168	0.136	1.103	0.964
483	0.035 •	0.248 •	0.213 •	1.955	1.711
645	0.040 •	0.328 •	0.288 •	2.964	2.636
726	0.043	0.371	0.328	3.790	3.412
726 [illegible] hours		0.373		4.920	4.547
1040				[illegible]	
00				[illegible]	

TABLE II.

Load lbs. sq ft	Wall Settlement in Inches					Deflection of Beams Inches at Middle		
	A	C	D	F	Mean	B	E	Mean
80	0.006	0.006	0.005	0.000	0.004	0.026	0.029	0.028
161	0.014	0.014	0.012	0.006	0.012	0.076	0.072	0.074
322	0.028	0.031	0.029	0.031	0.030	0.172	0.159	0.166
00	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000
726	0.040	0.045	0.041	0.045	0.043	0.398	0.344	0.371

TABLE III

Stretch in Cables on Spans of 20 Inches

Load lbs sq ft		Span Numbers								
		1	2	3	4	5	6	7	8	9
80	Inches	0.0006	0.0008	0.0000	[illegible]	0.0012	0.0026	0.0033	0.0027	0.0051
	%	0.0030	0.0040	0.0000	0.0080	0.0060	0.0130	0.0165	0.0135	0.0255
161	Inches	0.0036	0.0053	0.0020	0.0059	0.0039	[illegible]	0.0063	[illegible]	[illegible]
	%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
322	Inches	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0269
	%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
00	Inches	0.0042	[illegible]	0.0020	0.0026	[illegible]	[illegible]	[illegible]	0.0022	0.0051
	%	0.0210	0.0266	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0255

• Values interpolated from Curves I & II

Fig. 2—Tabulations for Loading Test.

Another exception to the customary installation consisted in the inability to place the cross rods in each panel as low as usually specified. Corrugated rods were used in place of the specified ⅝-in. diameter round rods (not obtainable at the time), and the corrugations had a tendency to cut the tie wires with which the cross rods were to be held down until the composition was placed. As a result of this difficulty the cross rods were placed with centers from 1¼ to 1¾ in. above the under surface of the floor slab instead of the specified distance of 1 in. This misplacement of the cross rods shortens the effective depth of the cables below their points of suspension over the I-beams, and the builders state that the allowable live load is dependent directly upon this effective depth, and that consequently the slab as built,

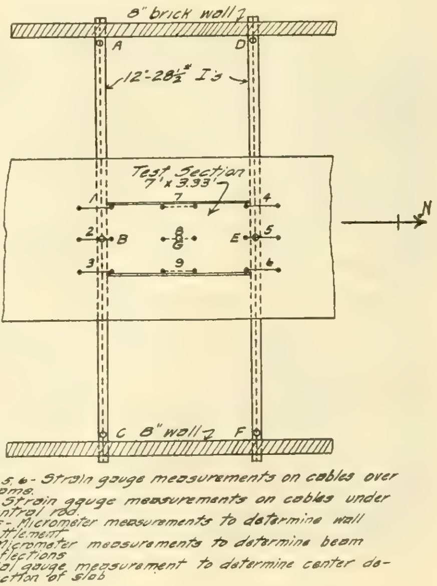

8" brick wall
A
D
12"-28½# I's
Test Section 7'x3.33'
1
7
4
2
B
8
G
E
5
3
9
6
N
C 8" wall F
1,2,3,4,5,6 - Strain gauge measurements on cables over beams.
7,8,9 - Strain gauge measurements on cables under central rod.
A,C,D,F - Micrometer measurements to determine wall settlement.
B,E - Micrometer measurements to determine beam deflections
G - Dial gauge measurement to determine center deflection of slab

Fig. 3—Points at Which Measurements Were Made.

with the cross rod 1¾ in. above the underside of the floor, would have an allowable live load of about 133 lb. per square foot, instead of the specified 150 lb. per square foot.

The construction of the floor consisted of three operations, viz.:

(a) Constructing the haunches or beam covering. This was effected by building forms around the webs and bottom flanges of all the I-beams and filling the forms with Metropolitan composition of a mushy consistency. This operation was completed in an hour, from 11 a. m. to 12 m.

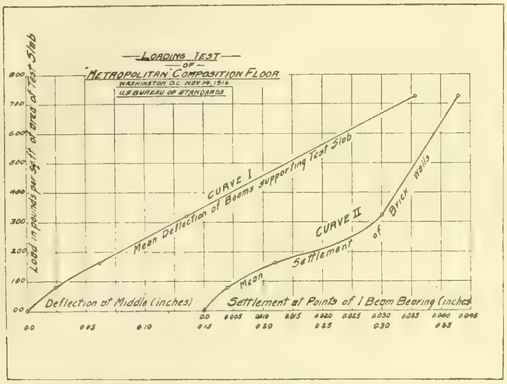


Fig. 4—Curves Showing Mean Deflection of Beam and Settlement of Brick Wall.

(b) Stretching the cables and inserting cross rods, from 1 to 2:30 p. m. The cables were first stretched taut over the tops of the I-beams, being secured by S-hooks of ¼-in. round steel to the outer edges of the top flanges of the two outermost beams. The center cross rod was then placed in each panel and brought down by means of tie wires to deflect the cables uniformly.

(c) Placing floor composition. Forms were built between the beams 4 in. below the top flanges and the composition of gypsum and wood chips was placed in these forms in a mushy condition and brought to a level of about ¼ in. above the top beam flanges.

The composition in the south panel was placed from 2:40 to 2:57 p. m. The balance of the panels were filled with the composition at an average rate of 20 minutes each. At 3:15 p. m. the south panel was firm enough to sustain a man walking on the surface, and from 3:17 to 3:25 all form work was removed from this section. At 3:30 p. m. 12 men of an average weight of 170 lb. stood in the center of the south panel, thus subjecting it to a load of about 85 lb. per square foot. The forms were removed from all sections of the floor by 4:35 p. m.

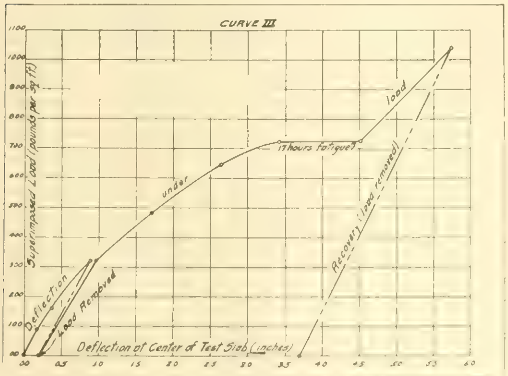


Fig. 5—Deflection Curves.

Size of Test Panel.—The section of floor which was loaded for test consisted of a strip 3 ft. 4 in. wide along the longitudinal center line of the center span, thus giving a section 7 by 3.33 ft. supported at two ends. This size section was chosen because of the size of iron ingots available for producing the load. The loading material consisted of cast iron elevator weights approximately 4 by 6 by 39 in. in size. A slot was made about ¾ in. wide on each side of the test slab the full depth of the floor, in order to free the slab from any side friction on the balance of the floor.

Age and Seasoning of Test Slab.—The floor was loaded for test Nov. 14, 1916, the floor when tested being then 25 days old. The floor was constructed in the open air and seasoned through a period of rather cool weather, with light rains for three days previous to the test. Tar paper shelters were used to protect the floor from precipitation and for a period of 4½ days previous to the loading of the slab the floor was heated with two salamanders under the center span. These salamanders maintained a temperature of 120° F. under the structure.

Loading of Floor for Test.—The iron ingots described above were placed on the test slab at right angles to the slab center line in layers of 10 weights each, producing load increments of approximately 80 lb. per square foot. Approximately 25 minutes to an increment were consumed in placing the load on the floor. The individual ingots were weighed and their respective weights recorded. Care was taken to leave space between adjacent weights in each layer to avoid any arching action in the load. Four load increments were placed on the slab, producing a total load of 322 lb. per square foot, which was a little in excess of twice the original computed allowable working live load. Deflection measurements were made on the slab and the two supporting I-beams for each increment of load. The total load was then removed and at the end of 35 minutes measurements were again made to determine the recovery of the slab and the various members. The floor was next loaded to 726 lb. per square foot and deflection measurements were again made. This load of approximately five times the allowable live load was left in place 17 hours, until the morning of Nov. 15, at which time the fatigue of the floor was determined. In an endeavor to destroy the slab the loading was continued to 1,040 lb. per square foot and the resulting deflections noted. The total load was finally removed and the recovery of the slab again determined.

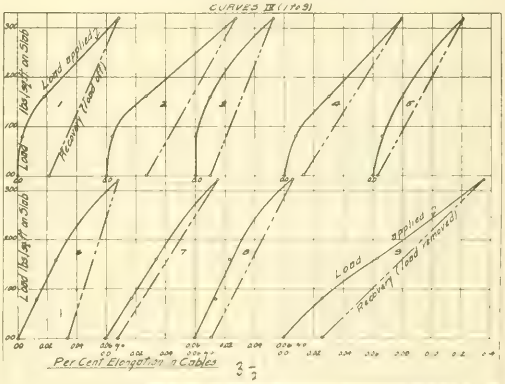


Fig. 6.

Instruments.—Determinations were made of the deflection of the slab at its center point, the deflection of the supporting beams, the settlement of the brick walls and the stretch produced in various steel cables, figures shown in Tables I, II and III, Fig. 2.

The deflectometer used at the center of the slab (point G on Fig. 3) consisted of an Ames dial gage working between two steel rods. The dial was suspended vertically by an adjustable and graduated steel rod from the under side of a 2 by 8-in. timber placed edgewise horizontally 5 ft. above the center of the test slab. This timber was supported by two A-frames 20 ft. apart. The piston of the gage worked in contact with the upper end of a vertical steel rod fastened by means of a flanged socket to the upper surface of the test slab at its center point. The dial was placed in compression with no load on the slab, and when the load increments caused the floor to deflect the pressure on the gage piston was gradually released and the lowering of the center point of the slab was indicated on the dial.

The deflection of the supporting beams at their middle points was determined by measuring with an inside micrometer calliper between the under side of the bottom beam flange and the end of a steel rod held vertically in a steel tripod resting on a concrete platform 30 in. square built temporarily on the ground. These measurement points are shown at B and E on Fig. 3.

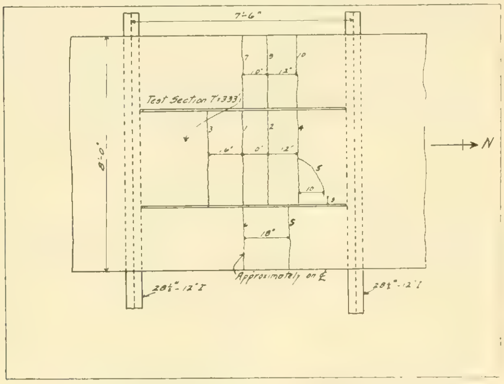


Fig. 7—Location of Cracks in Underside of Test Slab.

The same type measurement was used to determine the settlement of the brick walls, measurements being made between the upper end of a similar vertical steel rod and the under side of the bottom flange of the beam at a point 5 in. in front of the inside face of the brick wall in each case. These measurement points are shown at A, C, D and F, on Fig. 3.

At points 1 to 9, inclusive, shown on Fig. 3, determinations were made of the stretch produced in various cables. Holes were drilled in the composition to expose two points 20 in. apart on each of the cables measured. At these exposed points double-screwed clips were attached to the cables. These clips were fitted with countersunk holes of size suitable to seat the points of a 20-in. Berry strain gage, which instrument indicated the elongation between clips as the load was applied. These clips were so placed as to grip firmly both wires in each cable measured, thus assuring that the double wire acted as a unit.

Measurement of Deformations.—As the various load increments were applied to the floor determinations were made of the center deflection of the test slab, the middle deflection of the two beams which supported the test section, the settlement of the brick walls at the points at which the supporting I-beam rested on the walls, and the elongation of the steel cables at 9 points. The results of these measurements are shown in Tables I, II and III, Fig. 2.

In Curves I and II, Fig. 4, are plotted respectively the mean deflection of the supporting beams and the mean settlement of the brick walls. These values are used in making allowance for external influences in computing the net deflection of the floor from the values indicated by the deflectometer, G.

The net deflection of the test slab is shown graphically in Curve III, Fig. 5. As indicated on this curve, at a load of 322 lb. per square foot, or somewhat more than double the allowable live load, the floor deflected 0.885 in. When the load was removed and the floor allowed to stand free for 35 minutes the floor returned to within 0.199 in. of its original unloaded position. Applying the load a second time caused a center deflection in the floor of 0.964 in. at a load of 322 lb. per square foot, which would seem to indicate a fatiguing action in the slab. With a load of 726 lb. per square foot, or approximately five times the allowable live load, the floor deflected 3.419 in., and leaving this load in place for 17 hours caused a fatigue of 1.128 in. in the slab. Applying a load of 1,040 lb. per square foot deflected the floor 5.75 in. at the center. The steepness of Curve III between these last two load points is probably attributable to the fact that at this stage of the loading the deflection of the floor was sufficient to lower the cables in the floor to a point where they were placed in practically direct tension, and consequently the section of the curve mentioned above represents simply a tension deformation of the steel cables. When the total load was removed the floor returned to a point 3.69 in. below its original unloaded position.

In Curve IV (1 to 9), Fig. 6, is shown the per cent elongation produced in the cables at six points spanning the supporting I-beams and at three points spanning the middle of the test slab. As shown on the curves, the stretch in the cables at the middle of the span was in general greater than at the points over the I-beams. This is especially noticeable in the early stages of loading. It could not be definitely ascertained as to whether spans 1, 7 and 4; 2, 8 and 5; and 3, 9 and 6 were in each case three spans on a common cable. However, these measurements were made on cables which were fairly representative of the wires at the three respective points. In Curve III is a peculiarity in that no elongation was apparent for the first increment of load. This may be due to the fact that some of the cables installed had slight irregularities or kinks in them. If this cable was in such a condition, it is evident that the kink would straighten out before direct tension would be noticeable in the span measurement.

Observations.—On Fig. 7 are shown the location of cracks as they appeared in the under side of the floor. Cracks 1, 2, 3, 4 and 5 appeared as fine hair cracks at a load of 322 lb. per square foot. After the removal of this load the cracks closed and practically disappeared, showing considerable elasticity in the body of the floor. At a load of 726 lb. per square foot these 5 cracks opened about 1/16 in. and cracks 6 and 7 appeared as fine lines on the surface. After 17 hours cracks 6 and 7 had opened about ⅛ in., 1 to 5 had opened about ⅜ in., and cracks 8, 9 and 10 had formed, 1/16 in. open. When loaded with 1,040 lb. per square foot cracks 1 to 5 opened to ⅝ in. and cracks 6 to 10 about ⅜ in. There was very little spalling of material from the under side of the floor, and most of the cracks formed practically parallel to the I-beams. Although cracks 6 to 10 were not in the actual test slab, they are of interest in that they show presence of a thrust action along the upper surface of the floor on both sides of the test section. This thrust was due to the overturning of the beams, as shown on Fig. 8.

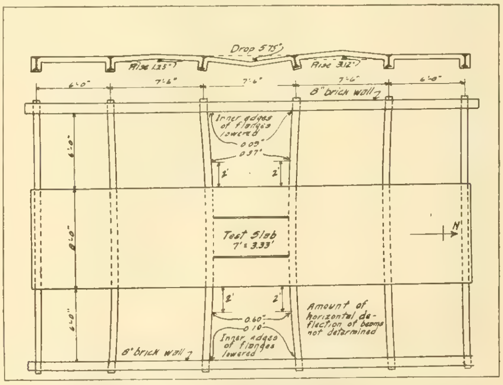


Fig. 8—Deformation of Panels and I-Beams with 1,040 lb. per sq. ft. on Test Slab.

With the load of 726 lb. per square foot in place for

30 minutes an arching action commenced in the two panels adjacent to the test section, the panel on the south rising ⅜ in. at its center and the panel on the north rising ¾ in. at its center. After 17 hours these distances increased to ¾ in. and 2 in., respectively. With the load of 1,040 lb. per square foot in place these rises increased to 1¼ in. and 3⅛ in., as shown on Fig. 8. These measurements were made with a steel scale and not by means of a micrometer calliper. The extreme end panels showed no arching action, although there was a slight horizontal deflection of the outside I-beams. The four inner I-beams suffered a more perceptible horizontal deflection, the south beams deflecting less than those to the north. After the removal of the total load the four outermost I-beams returned to practically their original straight condition, but the two beams supporting the test slab suffered a permanent distortion.

Condition of Structure After Test.—Two days after completions of the loading test sections 30 in. square were cut from the center and ends of the test panel and from the center of each of the other four panels. In the sections taken from the test panel and the two adjacent panels there was no sign of the cables or cross rods having cut up through the gypsum composition, the cross rods still being apparently the same distance above the bottom of the floor as when first measured, shortly after the floor was built. This was rather substantiated during the load test by the fact that when the cables in the panels adjacent to the test panel straightened horizontally under tension the slabs arched up, thus leaving the upper surface of the slabs in practically the same position relative to the cables and cross rods.

The cables in the various cut-out sections showed considerable rigidity or bond when jerked or shaken by means of a pair of pliers applied at alternate exposed sections 3 in. long, separated by sections 3 in. long, in which the cables were left covered with the composition. However, since, as noted above, there was an apparent horizontal tightening of the cables in the two slabs adjacent to the test panel, there must have been a movement of the cables horizontally over the top flanges of the I-beams.

SUGGESTED SPECIFICATIONS FOR CONCRETE FLOORS.

The Portland Cement Association has issued recently a pamphlet containing its suggested specifications for concrete floors. The specifications apply to floors in buildings, whether subjected to moderate or heavy traffic, and cover the laying and finishing of the floor; and also its protection during early hardening. Some of the clauses from these specifications follow:

Protection.

Treatment: As soon as the finished floor has hardened sufficiently to prevent damage thereby, the floor shall be covered with at least 1 in. of wet sand, or 2 in. of sawdust, which shall be kept wet by sprinkling with water for at least 10 days.

Protection: The freshly finished floor shall be protected from hot sun and drying winds until it can be sprinkled and covered as above specified. The concrete surface must not be damaged or pitted by raindrops, and the contractor shall provide and use when necessary sufficient tarpaulins to completely cover all sections that have been placed within the preceding 12 hours.

Concrete Slab.

Proportions: The concrete shall be mixed in the proportions by volume of 1 sack of Portland cement, 2 cu. ft. of fine aggregate and 4 cu. ft. of coarse aggregate.

Placing: The concrete shall be placed in a manner to insure a smooth ceiling, and thoroughly worked around the reinforcement and into the recesses of the forms. Concrete shall be deposited in its full position as soon as possible after mixing and within 30 minutes after the water has been added to the dry materials. It shall be struck off to a surface at least 1 in. below the established grade of the finished surface of the floor. Workmen shall not be permitted to walk in freshly-laid concrete, and if sand or dust collects on the base, it shall be carefully removed before the wearing course is applied.

Wearing Course.

Proportions and Thickness (Mixture No. 1): The mortar shall be mixed in the proportions of 1 sack of Portland cement and 2 cu. ft. of fine aggregate. The minimum thickness shall be ¾ in.

Proportions and Thickness (Mixture. No. 2): The mortar shall be mixed in the proportions of 1 sack of Portland cement, 1 cu. ft. of fine aggregate and 1 cu. ft. of No. 1 aggregate for wearing course. The minimum thickness shall be 1 in.

Consistency: The mortar shall be of the dryest consistency possible to work with a sawing motion of the strikeboard.

Placing: The wearing course shall be placed immediately after mixing. It shall be deposited on the fresh concrete of the base before the latter has appreciably hardened, and be brought to the established grade with a strikeboard.

Preparation of Slab: The surface of the slab shall be thoroughly roughened by picking, and swept clean of all dirt and debris.

Placing: The slab shall be thoroughly moist, but free from pools of water when the grout and mortar for wearing course is placed. A neat cement grout shall be brushed on the surface of the slab, the wearing course immediately applied and brought to the established grade with a strikeboard. Grout and mortar shall be used within 45 minutes after mixing with water.

Finishing: After the wearing course has been brought to the established grade by means of a strikeboard, it shall be worked with a wood float in a manner which will thoroughly compact it and provide a surface free from depressions or irregularities of any kind. When required, the surface shall be steel-troweled, but excessive working shall be avoided. In no case shall dry cement or a mixture of dry cement and sand be sprinkled on the surface to absorb moisture or to hasten the hardening, but the Bruner method may be used if desired.

Coloring: If artificial coloring is used, it must be incorporated with the entire wearing course and shall be mixed with the cement and aggregate until the mixture is of uniform color. In no case shall the amount of coloring exceed 5 per cent of the weight of the cement.

Plain Concrete Floors.

Size of Slabs: The slabs or independently-divided blocks when not reinforced shall have an area of not more than 100 sq. ft., and shall not have dimensions greater than 10 ft. Larger slabs shall be reinforced.

Thickness of Floor: The thickness of the floor shall be not less than 5 in.

Width and Location of Joints: When required by the architect or engineer in charge, a ½-in. space or joint shall be left between the floor and the walls and columns of the building, to be filled with the "joint filler."

Protection of Edges: Where required by the architect or engineer in charge, the edges of the slabs at the joints shall be protected by metal. Unless protected by metal, the upper edges of the slabs shall be rounded to a radius of ½ in.

Concrete Base (Two-Course Floor).

Proportions: The concrete shall be mixed in the proportions by volume of 1 sack of Portland cement, 2½ cu. ft. of fine aggregate and 5 cu. ft. of coarse aggregate.

Reinforcing: Slabs having an area of more than 100 sq. ft., or having dimensions greater than 10 ft., shall be reinforced with wire fabric, or with plain or deformed bars. The reinforcement shall have a weight of not less than 28 lb. per 100 sq. ft. The reinforcement shall be placed upon and slightly pressed into the concrete base immediately after the base is placed. It shall not cross joints and shall be lapped sufficiently to develop the full strength of the metal.

Wearing Course.

Proportions for Mixture No. 1: The wearing course shall be mixed in the proportions of 1 sack of Portland cement, 2 cu. ft. of fine aggregate. The minimum thickness shall be ¾ in.

Proportions for Mixture No. 2: The wearing course shall be mixed in the proportions of 1 sack of Portland cement and 1 cu. ft. of fine aggregate, and 1 cu. ft. on No. 1 aggregate for wearing course. The minimum thickness shall be 1 in.

Finishing: After the wearing course has been brought to the established grade by means of a strikeboard, it shall be worked with a wood float in a manner which will thoroughly compact it and provide a surface free from depressions or irregularities of any kind. When required, the surface shall be steel-troweled, but excessive working shall be avoided. In no case shall dry cement or a mixture of dry cement and sand be sprinkled on the surface to absorb moisture or to hasten the hardening, but the Bruner method may be used if desired. Unless protected by metal the surface edges of all slabs shall be rounded to a radius of ½ in.

One-Course Floor.

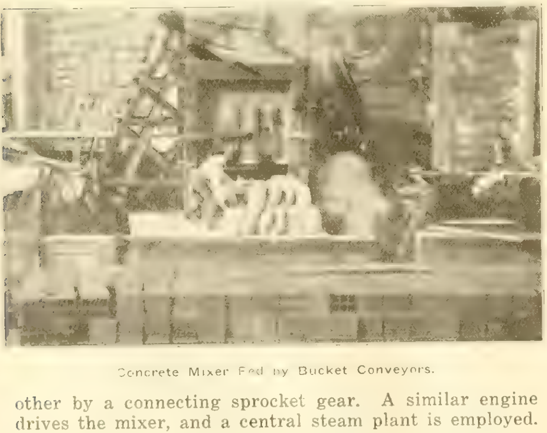
Proportions: The concrete shall be mixed in the proportions of 1 sack of Portland cement to not more than 2 cu. ft. of fine aggregate and not more than 3 cu. ft. of coarse aggregate, and in no case shall the volume of the fine aggregate be less than ½ the volume of the coarse aggregate.

A cubic yard of concrete in place shall contain not less than 6.8 cu. ft. of cement.

TWO BUCKET CONVEYORS FEED CONCRETE MIXER.

Contributed by W. F. Schaphorst

The arrangement shown in the view permits fast charging of the concrete mixer used in building a high school in Nashville. A bucket conveyor on each side of the mixer rises from a pit to a position above the charging hopper of the mixer. Motor trucks dump the sand on one side and the gravel on the other. A 6-hp. engine drives the conveyors, one by means of a belt and the other by a connecting sprocket gear. A similar engine drives the mixer, and a central steam plant is employed.



Concrete Mixer Fed by Bucket Conveyors.

Only one man is required to manipulate the material hoppers, while a second man discharges the batch. An engine runner and fireman operates both the hoisting engine and the central boiler. The plant was rigged from old machinery and cost only $100.

The Siems-Carey Co., St. Paul, Minn., has been awarded a contract by the Chinese government for an additional 300 miles of railway. This makes 2,300 miles of line this company will construct in China.

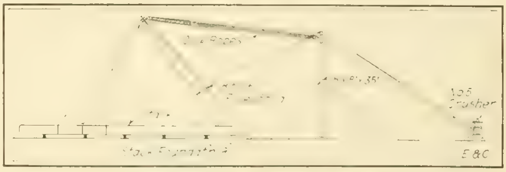
METHOD OF ERECTING A 110-FT. STEEL STACK.

The new plant of the Ottawa Stone & Sand Co. now under construction at Ottawa, Ill., will have a 110-ft. steel smokestack. The method employed in erecting the stack is described below. The stack has an overall length of 110 ft. and a diameter of 60 in. The thickness of the shell is as follows: First third of length, ⅜ in.; 2d third, 5/16 in.; 3d third, ¼ in.

The stack came in six sections of about equal lengths. These were laid in line with the base of the bottom section as close as practical to the foundation, and riveted together on the ground. The foundation projected 12 in. above the ground, and was made round and smaller in diameter than the inside of the smokestack to assure a loose and easy fit.

After being riveted and lined out and painted, the stack was provided with straps and slings for receiving the wire cables.

There were no braces or reinforcements on the inside of the stack, with the exception of the section nearest to the base, which had an opening for receiving the flue box from the boiler. Here three braces in the shape of a cross were used.



Arrangement for Erecting Stack.

A single drum-band hoist was located on the foundation of a No. 5 gyratory crusher and an 8x8 pole 35 ft. long was erected about two-thirds of the distance from the foot of the stack to the crusher. This pole had eight guy wires anchored to the ground and to the crusher. At the top of this pole there was fastened a 4-block shackle and two snatch blocks with large sheaves for 1⅛-in. diameter rope.

At the smokestack, two 55-ft. 8-in. to 16-in. telegraph poles were used. These were braced horizontally and bolted together in the shape of an "A" frame, and laid out alongside the smokestack.

On the top of this "A" frame there was fastened a 5-block shackle and one double block for cables leading to the smokestack. These cables were fastened at the top half of this stack, dividing same in about two equal parts. The 5-part block was part of the tackle doing the final hoisting.

To equalize the pull and variation of the length of these cables while the stack was being raised, a single block was fastened to the smokestack located half way between the two outside cables. These connections of cables were made while the "A" frame was laid out alongside with its base against the foundation of the stack.

The hoisting rope was 1⅛ in. in diameter manila transmission rope of a total length of about 1,400 ft. This was pulled through the blocks, one end being anchored to the crusher, the other end leading to the hoist. The first and last line of these ropes were led over snatch blocks on the 35-ft. pole, with eight ropes pulling direct against this pole.

With everything ready, as described above, the hoisting was begun by four men, two on each side of the hoist. The "A" frame was raised into a position of 45° to the horizontal, before the raising of the stack commenced. The greatest stress occurred in all cables and ropes at this point, and if the theoretical calculations of the stresses had not been correct the rigging would have broken down at that point. As there was no fault visible the hoisting was continued and in three hours' time the smokestack was in place with all guys temporarily fastened.

The total cost, including the riveting, painting, erecting of the masts, and raising and fastening of guys, not including any material, was $175. The foreman on the job, who is an expert millwright, was paid 75 ct. an hour and common labor 35 ct. per hour.

The erection was planned and personally directed by Mr. Theodore Ahlborn, Chicago, the contractor, in charge of the construction of the plant.

THE ST. CHARLES BRIDGE FIRE.

On Sept. 26 the bridge over the Missouri River at St. Charles, Mo., was badly damaged by a fire in its wooden floor system. The following details of the accident are taken from the Quarterly of the National Fire Protective Association. The bridge forms the main outlet for street car and wagon traffic to St. Louis County and St. Louis City. It was built in 1903 at an approximate cost of $500,000, not including approaches, and is owned by the St. Louis & St. Charles Bridge Co., a corporation with offices in St. Louis.

The total length of the bridge is 2,612 ft., divided into three 416-ft. through steel spans, one 300-ft. through steel span, one 164-ft. steel span, inverted truss, one 656-ft. timber trestle (west approach), and one 366-ft. timber trestle (east approach). All spans are supported on cylindrical steel piers filled with concrete, except one concrete pier at the east end of the inverted truss. The spans consist of two trusses 22 ft. 6 in. on centers, with latticed and boxed steel members. Floor girders were built up 40 in.; plates about 30 ft. on centers.

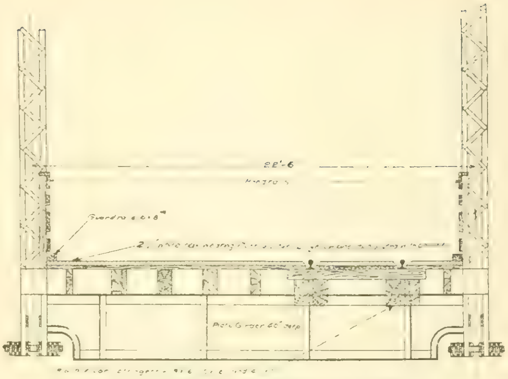


Fig. 1—Typical Cross Section of Bridge.

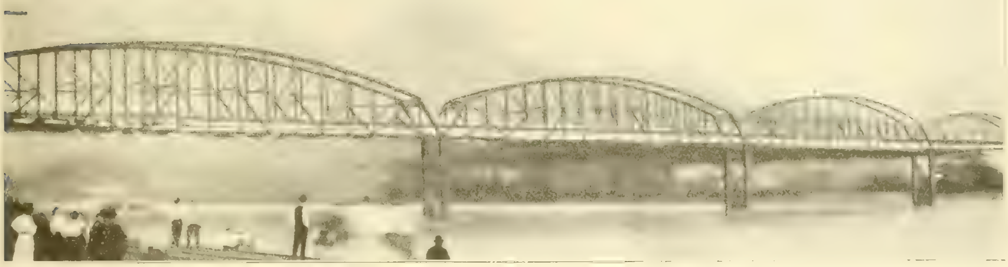


Fig. 2—View of Bridge About 1½ Hours After Fire Started and Before South Wooden Hand Rail Collapsed.

Wooden flooring, consisting of 2½-in. white oak wearing planking over 2-in. yellow pine plank impregnated with creosote and supported by eight or nine wooden 4-in. by 16-in. and 9-in. by 16-in. stringers running longitudinally, was laid new in 1914. These stringers or sills rested directly on steel floor girders. There were

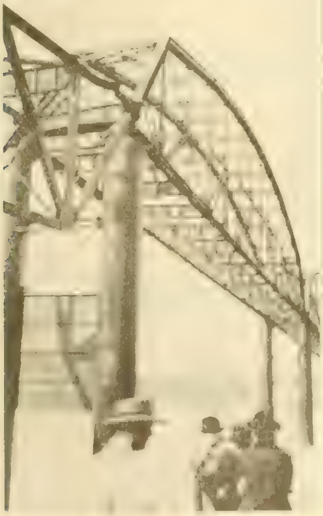


Fig. 3—End of Inverted Truss and First East Through Span.

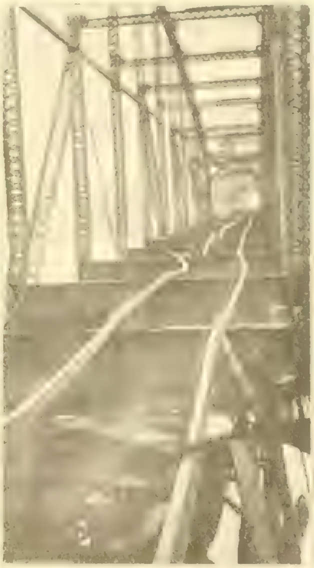


Fig. 4—West Through Span.

railroad ties 6-in. by 8-in. 2-ft. on centers under street car rails, and wooden hand rails above on each side. A typical cross section is shown in Fig. 1.

Details of Fire.—The fire started about the middle of the west through span. The cause is unknown. The flooring was worn and splintered in many places; new lumber was piled on the bridge to replace what had been worn out. It is probable that a match, cigar or cigarette was thrown from an electric car which passed over the bridge at about 5 p. m. or by some teamster or foot passenger, and that this lodged in a worn spot and smoldered through to the lower floor layer of soft creosoted wood. It is stated that the St. Charles fire department has been called upon to extinguish several such fires on the bridge. The fire had gained considerable headway before the department arrived in quick response to a telephone alarm at 5:15 p. m. The wind was blowing strongly from the south at right angles to the length of the bridge with an estimated velocity of 20 to 30 miles an hour. The fire swept both east and west, being under control at the west end at 9 p. m. and entirely extinguished at 11 p. m. Apparently no damage was done west of the west span, nor to the west approach. Toward the east it is stated that the fire traveled at the rate of about 30 minutes per 400-ft. span, entirely stripping the bridge of combustible material and destroying the east approach. No trusses collapsed, but evidently serious damage was done to the north truss of each span and to floor girders, as was evidenced by many warped and some buckled members. The high wind across the bridge, by blowing the heat away, evidently prevented its complete collapse.

METHODS OF SUPPORTING BRICK AND TRIM IN PIERS AND SPANDRELS OF REINFORCED CONCRETE BUILDINGS.

Contributed by Albert M. Wolf

In the present-day reinforced concrete buildings, the exterior walls are in general merely brick and glass enclosing curtains supported on the concrete framework and do not assist in carrying the loads coming upon the structure as in the old type of wall-bearing construction. This means that the thickness of brick piers and spandrels can be the minimum allowed by the height and architectural treatment.

Where the exterior columns are of rectangular shape and form, the piers and the floor slabs are exposed as lintels over the windows in the story below and the support of the brick spandrel walls is a simple matter, the same being built up on the floor slab between the concrete piers or columns. (See Fig. 1.) Ordinarily a wall 9 in. thick will suffice for such construction unless the spandrels are over 5 ft. high when it is well to use a 13-in. wall to obtain greater stability. If the building is to be used for storage purposes wherein materials may be piled up against the spandrels, special attention should be given to the anchorage of same to columns and floor slabs either by key-ways or stub bars anchored into the concrete and built into the brickwork.

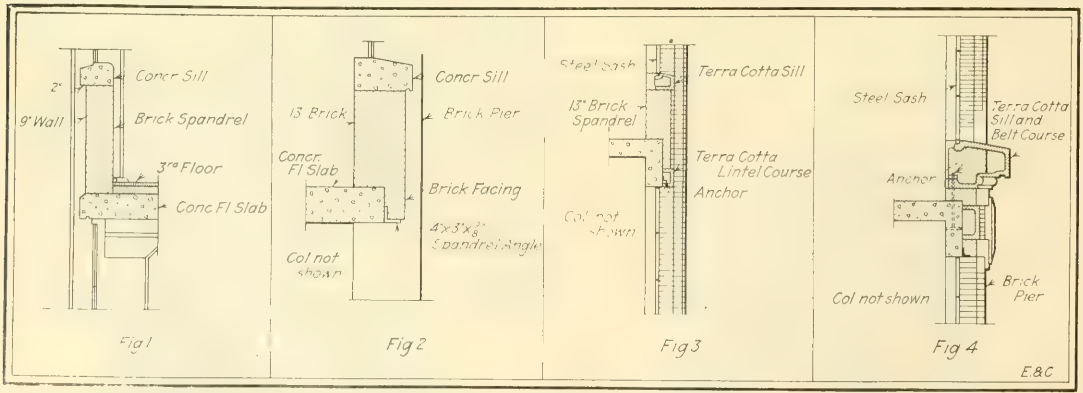


Fig. 1—9-in. Brick Spandrel Wall—Concrete Floor Slab and Column Exposed. Fig. 2—Brick Spandrel Wall and Pier—Brick Facing of Lintel Supported on Spandrel Angle. Fig. 3—Brick Spandrel Wall and Pier—Terra Cotta Lintel Course Supported on Spandrel Angle. Fig. 4—Terra Cotta Sill and Belt Course on Brick Spandrel Anchored to Concrete Spandrel Girder.

If the architectural treatment is such that no concrete supporting members are exposed, then the problem of proper support for the brick and trim of the exterior walls is more difficult. This means that the concrete work must be so laid out that it is at all points at least the width of a brick (usually 4½ to 5 in.) behind the outer face of the wall, and some method of supporting the brickwork and trim over openings in the walls must be used which will not show on the face of the wall. For spandrels of this character, it is hardly feasible to use brick walls less than 13 in. thick; that is the backing portion resting directly on the concrete floor, should be at least 8 to 8½ in. thick to give the proper stability, since face brick is not generally bonded to the backing except by brick ties.

In Fig. 2 a spandrel wall of the character just mentioned is shown. It will be seen that the face brick rowlock course over the windows is supported on 4-in. x 3-in. x ⅜-in. angles anchored to the concrete floor slab with bent plate anchors spaced 18-in. centers and that the backing of common brick, 8½ in. thick, is carried directly on the concrete slab, the face brick course being tied to the backing with corrugated metal brick ties. A modified spandrel of this type with a terra cotta lintel course is shown in Fig. 3. The terra cotta, it will be noted, is hung from the supporting angle thus covering and protecting it from damage by fire and rust to which the angle is exposed when placed as shown in Fig. 2.

In either of the types of construction shown in Figs. 2 and 3, it is good practice to anchor the brick work of piers to the concrete columns, at least where the veneer is thin, by means of metal brick ties anchored into the columns. It is also a wise precaution to provide supporting angles at floor lines for the brick facing of the piers. When wood column forms are used, the brick ties can be bent and tacked to the forms with the width of ties placed vertically so as to expose as little of the ties as possible to the falling concrete when the forms are filled, thus insuring better anchorage in the concrete. If metal column forms are used, the placing of brick ties in the columns is more difficult, but can be accomplished by tacking them to a thin wooden strip wired to the front portion of the form, through small holes provided for that purpose, the strip being pulled out with the removal of the form leaving the ties in place to be bent out into the brick joints.

When the architectural treatment necessitates the use of projecting belt courses at the top of spandrel walls care should be exercised to see that the course is securely anchored to the spandrel, and further, that the center of gravity of the entire spandrel section lies in a plane well back of the facing course, or, in other words, in one intersecting the concrete slab, and not the spandrel angle; or if deep spandrel girders are used the wall may be anchored as shown in Fig. 4.

Where it is impossible to do this, the facing materials and projecting courses should be anchored to concrete beams raised above the floor as a part of the spandrel and reinforced to act as beams between columns with the load applied at the side. Such beams are subjected to bending in horizontal planes as well as vertically and should be well reinforced with vertical stirrups in addition to the main bars.

CHARTS FOR REINFORCED CONCRETE DESIGN.

Contributed by Roy E. Ward, 719 Capeland St., Pittsburgh, Pa.

The accompanying charts are constructed on the nomographical principle. Besides being useful in reinforced concrete design, they serve to illustrate different forms of the nomograph and the possibilities of treating complicated formulæ by this principle.

A number of nomographs have been published, but very little has been said about the method of making them. A discussion of these charts, though brief, may therefore be of interest.

The method followed is, in the main, that given by Prof. John B. Peddle in his book, entitled "The Construction of Graphical Charts," and may be outlined as follows: Fig. 1 represents a nomograph for the general equation

$$au + bv = c \quad \text{.................}(1)$$

Values of u are given on the AU axis and values of v on the BV axis. The location of the point P is such that straight lines drawn through it and intersecting the u and v scales give corresponding values of u and v. Its location is given by the equations

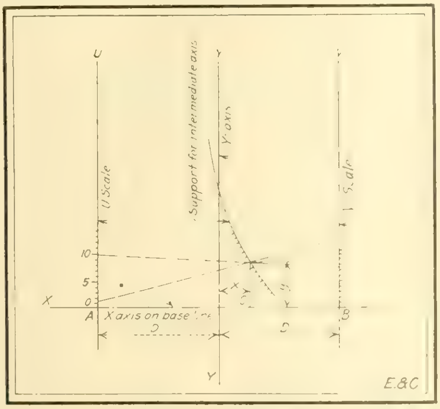


Fig. 1—Nomograph for General Equation au + bv = c.

$$x = D\frac{b}{b + a} \quad \text{.................}(2)$$

$$y = \frac{c}{b + a} \quad \text{..........}(3)$$

The intermediate axis is the locus of the point P.

By inspecting equations (2) and (3) the nature of the intermediate axis may be determined as follows:

(I) If c is zero, then y becomes zero, and the intermediate axis coincides with the base line.

(II) If a and b are constant and u, v and c vary, then x is constant and all values of y lie on a line at a distance x from the Y axis.

(III) If in addition to u, v and c, a or b is varied, then the point p moves to the right or left as well as vertically.

(IV) If a, b and c are constant and u and v vary, then x and y remain constant or all lines connecting corresponding values of u and v pass through a common point whose co-ordinates are (x, y).

The chart shown in Fig. 2 is an illustration of case I. By means of it it is possible to solve the following formulæ:

$$M = \frac{wL^2}{K} 12 \quad \text{.................}(4)$$

$$d = C\sqrt{\frac{M}{b}} \quad \text{.................}(5)$$

$$A_s = pbd \quad \text{.......................}(6)$$

in which

M = bending moment in in.-lbs.

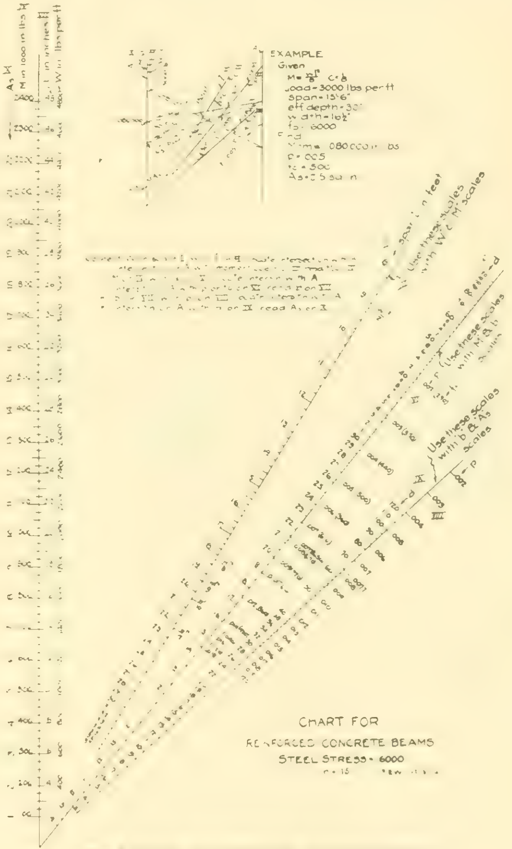


Fig. 2—Chart for Reinforced Concrete Beams.

w = load in lbs. per ft.
L = span of beam in feet.
K = depends on method of support of beam.
d = depth to steel in inches.
b = width of beam in inches.
C is constant for given concrete and steel stresses.
A_s = steel area to resist bending moment.
p = ratio of steel to concrete area.

This chart is a combination of six nomographs, two for each of the formulæ (4), (5) and (6). To illustrate the method of making this chart, take equation (5). Put it in the form

$$MC^2 = bd^2$$

$$\text{Let } \frac{M}{d^2} = q \text{ or } M - qd^2 = 0 \quad \text{.............}(7)$$

$$\text{then } q = \frac{b}{C^2} \text{ or } b - qC^2 = 0 \quad \text{.............}(8)$$

The first step in solving equation (5) is to construct a nomograph for (7) giving values of q when M or d is known. To complete the solution it is necessary to construct a nomograph for (8) giving values of b when C or q is known.

Taking equation (7) and referring to Fig. 2, values of M are plotted on the AU axis, values of q on the BV axis and values of d on the intermediate axis or support, which in this case coincides with the base line, since c is zero. To plot these values it is necessary to decide upon the scales by which they are to be measured as lengths on their respective axes. To obtain u, the measured length of M on the AU axis, values of M must be multiplied by some modulus l_1. Likewise let $-l_2$ be the modulus for values of q.

$$\text{Then } u = l_1 M \text{ or } M = \frac{u}{l_1}$$

$$\text{and } v = -l_2 q \text{ or } q = \frac{v}{-l_2}$$

substituting in (7), we have

$$\frac{u}{l_1} + \frac{vd^2}{l_2} = 0 \text{ or } l_2 u + l_1 d^2 v = 0$$

which is in the form of equation (1)

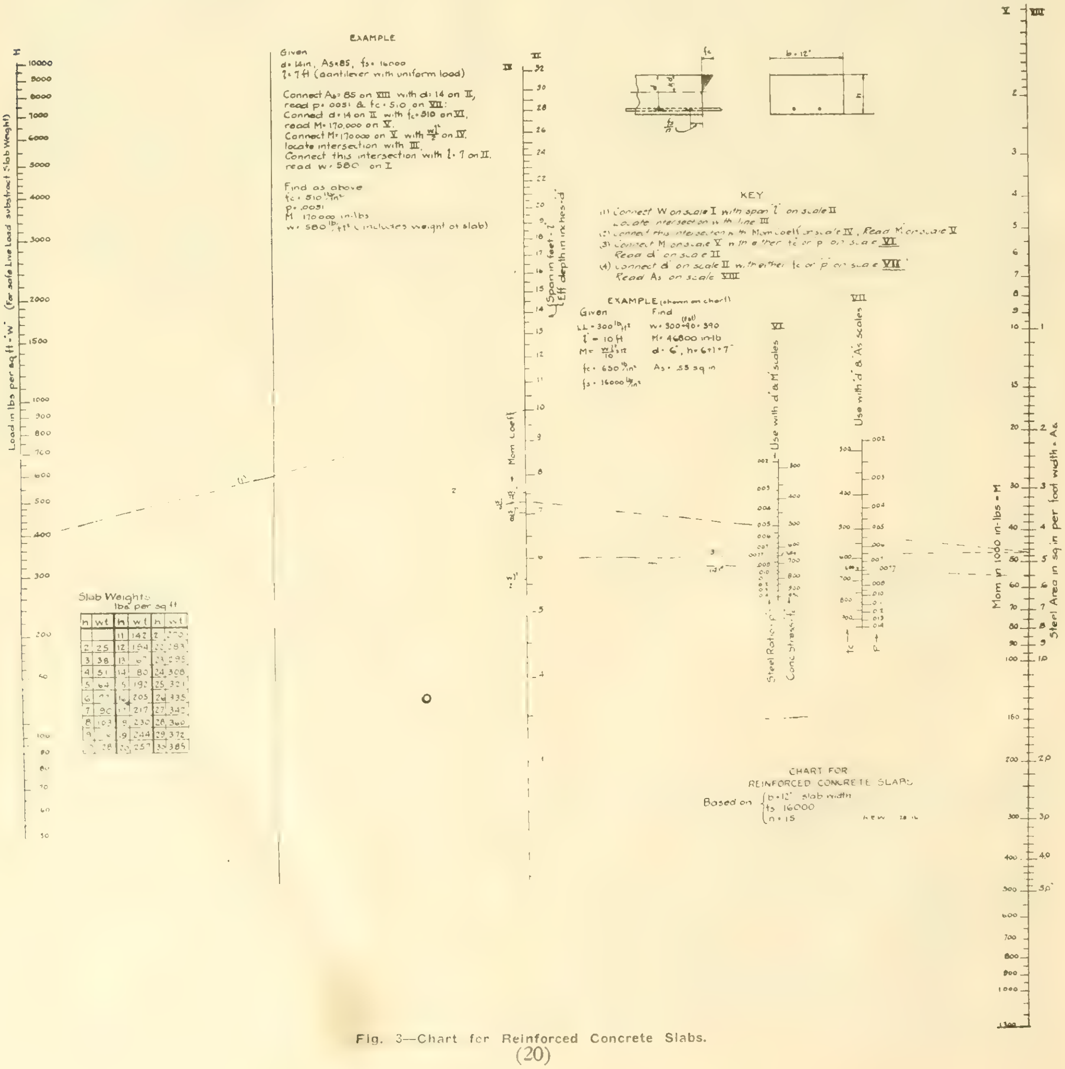
$$\text{from (2) } x = D \frac{l_1 d^2 - l_2}{l_1 d^2 + l_2} \quad \text{.....................(9)}$$

from (3), $y = 0$.

The moduli may be anything we choose to make them, but practical considerations such as size of chart desired, closeness of scale reading, graduations on the intermediate axis, etc., govern. They should therefore be chosen by trial.

In the chart under consideration the limits of M are 0 in.-pounds and 2,400,000 in.-pounds. Taking as a scale for the AU axis 1 in. = 160,000 in.-pounds or $l_1 = \frac{1}{160{,}000}$, gives 15 in. for the length of this axis. The length of the intermediate axis will be taken at 15 in. making D = 7.5 in. After a number of trials for values of x in (9), using different values of the ratio $\frac{l_2}{l_1}$, 400 will be chosen for $\frac{l_2}{l_1}$ as giving the best graduation for d on the intermediate axis.

Graduating the M scale is a simple matter, the scale being uniform as is shown by the equation $u = l_1 M$. The q scale is not graduated as the determination of q is only an intermediate factor in the equation $d = C\sqrt{\frac{M}{b}}$ which is being solved. The d axis must be graduated by



EXAMPLE

Given
d = 14 in, As = .85, fs = 16000
l = 7 ft (cantilever with uniform load)

Connect As = .85 on VIII with d = 14 on II,
read p = .0051 & fc = 510 on VII:
Connect d = 14 on II with fc = 510 on VI,
read M = 170,000 on V.
Connect M = 170000 on V with $\frac{wl^2}{2}$ on IV.
locate intersection with III.
Connect this intersection with l = 7 on II.
read w = 580 on I

Find as above
fc = 510 lb/in²
p = .0051
M 170000 in-lbs
w = 580 lb/ft² (includes weight of slab)

KEY

(1) Connect W on scale I with span l on scale II
locate intersection with line III
(2) connect this intersection with Mom coeff on scale IV, Read M on scale V
(3) Connect M on scale V with either fc or p on scale VI
Read d on scale II
(4) connect d on scale II with either fc or p on scale VII
Read As on scale VIII

EXAMPLE (shown on chart)

Given	Find
LL = 300 lb/ft²	w = 300+90 = 390 (tot)
l = 10 ft	M = 46800 in-lb
M = $\frac{wl^2}{10}$ × 12	d = 6", h = 6+1 = 7"
fc = 650 lb/in²	As = .55 sq in
fs = 16000 lb/in²	

Slab Weights
lbs per sq ft

h	wt	h	wt	h	wt
		11	142	21	270
2	25	12	154	22	283
3	38	13	[illegible]	23	295
4	51	14	[illegible]	24	308
5	64	15	192	25	321
6	[illegible]	16	205	26	335
7	90	17	217	27	[illegible]
8	103	18	230	28	360
9	[illegible]	19	244	29	372
10	128	20	257	30	385

Fig. 3—Chart for Reinforced Concrete Slabs.

figuring points, for various values of d, from equation (9). For example take the point for $d = 40$.

$$x = 7.5 \frac{d^2 - 400}{d^2 + 400} \text{ since } l_2 = 400\ l_1 \text{ and } D = 7.5 \text{ in.}$$

which gives $x = +4.5$ in. for $d = 40$.

This means that the point for $d = 40$ is 4.5 in. to the right of the center point of the intermediate axis.

Equation (8) is treated similarly using the same axes as used for equation (7) and using the same scale graduations for b as were used for M. This latter is done as follows,

$$\text{for equation (7) } l_2 = 400\ l_1 \text{ or } l_2 = \frac{1}{400} \text{ since } l_1$$

$$\text{for (7)} = \frac{1}{160{,}000}$$

$$\text{then assuming for } l_1 \text{ for (8) 1 in.} = \frac{16}{5} \text{ or } l_1 = \frac{5}{16},$$

$$\frac{l_2}{l_1} = \frac{1}{400} \div \frac{5}{16} \text{ from which } l_2 = 0.008\ l_1 \text{ for (8).}$$

The value for l_2 must be the same for both equations (7) and (8) since it is the scale unit for q which occurs in both. By making l_1 for (8) a multiple of that used for (7), as was done above, it is possible to use the same graduations for M and b.

In this chart f_s is assumed at 16,000, which means that all beams designed by it have a steel stress of 16,000 lb. per square inch. Beams may be designed, however, for various values of f_c. After using values of C (for $f_s = 16{,}000$ and $n = 15$)* for locating points on the intermediate axis, they are discarded and corresponding values of p and f_c are written opposite these points for use on the chart.

Nomographs for equations (4) and (6) are constructed in the same way. The same AU axis and the same AU graduations are used throughout. Since it is impracticable to use the same intermediate axis for all the equations, the zero point on the BV axis is changed and new intermediate axes drawn to the same zero point on the AU axis.

Examples are given on the chart to show how to use it. It may be used in any order provided the right scales are connected. For example, the M or scale IV must always be connected with the d or scale V and vice versa. The range of the chart may be increased by the fact that

$$d = C \sqrt{\frac{nM}{nb}} \text{ in which n is any number.}$$

The chart in Fig. 3 is also a combination of several nomographs. It solves the following formulae:

$$M = \frac{wL^2}{K} 12 \qquad (10)$$

$$d = C \sqrt{\frac{M}{12}} \qquad (11)$$

$$A_s = pd12 \qquad (12)$$

The notation is as given for equations (4), (5) and (6) except that b is taken at 12 in. and w in lbs. per square foot.

Taking equation (10) as an illustration and dividing into two equations of three variables each we have,

$$wL^2 = q \qquad (13)$$

$$M = \frac{q^{\cdot 12}}{K} \qquad (14)$$

Writing by means of logarithms,

$$\log w + 2 \log L = \log q \qquad (15)$$

Log w will be plotted on axis I, log L on axis II, and log q on axis III. Assuming 1 in. equal to a difference in logarithms of 0.15 as a scale for log w and 1 in. = 0.075 for log L as giving the size of chart desired, we have,

$$l_1 = \frac{1}{0.15} = \frac{20}{3}, \text{ and } l_2 = \frac{40}{3}, \text{ or } l_2 = 2\ l_1$$

$$\text{Let } u = l_1 \log w, \text{ or } \log w = \frac{u}{l_1}$$

$$\text{Let } v = l_2 \log L, \text{ or } \log L = \frac{v}{l_2}$$

$$\text{Let } c = \log q$$

Then substituting in (15)

$$l_2 u + 2\ l_1 v = l_1 l_2 c \qquad (16)$$

which is similar to equation (1) and falls under case II.

From (2),

$$x = D \frac{2\ l_1 - l_2}{2\ l_1 + l_2}, \text{ or } \frac{2\ l_1}{l_2} = \frac{D + x}{D - x} = \frac{CA}{CB} = \frac{2\ l_1}{2\ l_1}$$

which gives the location of axis II as half way between I and III. Make $CA = CB = 5$ in.

From (3),

$$y = \frac{l_1 l_2\ c}{l_2 + 2\ l_1}$$

which shows that values of c must be multiplied by $\frac{l_1 l_2}{l_2 + 2\ l_1}$ or the modulus of $c = l_3 = \frac{l_1 l_2}{l_2 + 2\ l_1} = \frac{10}{3}$ or 1 in. = 0.3.

The thirtieth scale of the engineer's scale may be used to graduate axis I by first multiplying logarithms of w by two. Axis II may be graduated from axis I by multiplying corresponding scale units by two since $l_2 = 2\ l_1$. As the scales are logarithmic, that portion of the scales between 1 and 10 is the same as that between 10 and 100, etc. Axis III is not graduated, since the numerical values are not desired. The zero points on axis I and II may be located wherever convenient, as the base line need not be horizontal, nor is it essential to know its location. Since both l_1 and l_2 are positive, both scales increase upward.

Writing (14) by means of logs,

$$\log q - \log M = \log K - \log 12 \qquad (17)$$

The modulus for q has been determined as above, $l_3 = \frac{10}{3}$

Assuming the modulus for log M as $-l_4 = \frac{20}{3}$, and determining a new value for CA ÷ CB, we have,

$$\frac{CA}{CB} = \frac{l_3}{l_4} = \frac{1}{2} = \frac{5 \text{ in.}}{CB} \text{ or } CB = 10 \text{ in.}$$

which means the M axis or axis V is 10 in. beyond axis IV, since axis IV is now the intermediate axis.

$$\text{The modulus for log } K = \frac{l_3 l_4}{l_3 + l_4} = \frac{20}{9} \text{ or 1 in.} = 0.45.$$

The M axis must be graduated downward or in the opposite direction to that of the positive scales, since log M has the minus sign. As before it is not necessary to know the location of the zero point. Values of log K — log 12 must be laid of on axis IV, the intermediate axis for equation (17). Perhaps the best way to do this, since the location of the zero point is not known, is to assume a given span, load, and moment coefficient K and locate this value of K by intersection. This method automatically takes care of the term —log 12. These locations may be checked by the fact that the scale for this axis is 1 in. = 0.45.

Nomographs for (11) and (12) are made in the same manner, using axes and scales twice where possible. For instance, the same axis and scale used for L works very well for d, as both are squared in the formulae.

Like the chart just described examples are given to illustrate its use. It may also be used in reversed order provided corresponding scales are connected.

The chart shown in Fig. 4 solves the following formulae

---

*See Taylor & Thompson "Concrete, Plain and Reinforced."

(see Taylor and Thompson, Concrete Plain and Reinforced).

$$k = \sqrt{2n\left(p + p'\frac{d}{d}\right) + n^2(p + p')^2} - n(p+p') \quad (18)$$

$$C_c = \frac{k}{2}\left(1 - \frac{k}{3}\right) + \frac{np'}{k}\left(k - \frac{d'}{d}\right)\left(1 - \frac{d'}{d}\right) \quad \ldots . (19)$$

$$f_c = \frac{M}{C_c bd^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (20)$$

$$f_s = nf_c\left(\frac{1 - K}{k}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (21)$$

$$f'_s = nf_c\left(1 - \frac{\frac{d'}{d}}{k}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (22)$$

In addition to the symbols already given,

k = ratio of depth of neutral axis to depth of tensile steel.
p′ = compressive steel ratio.
d′ = depth to compressive steel in inches.
C_c = an intermediate factor.

The two nomographs in the upper half of the chart each solve equations of four variables and give values of C without interpolating, as must be done where tables are used.

Equation (18) is solved by the nomograph in the upper left-hand corner. After squaring, transposing, and combining terms (18) reduces to

$$p(1 - k) + p'\frac{d'}{d} = \frac{k^2}{30} + p'k \quad \ldots\ldots\ldots\ldots (23)$$

Let $u = l_1 p$ and $v = l_2 \frac{d'}{d}$

then $p = \frac{u}{l_1}$ and $\frac{d'}{d} = \frac{v}{l_2}$

Substituting in (23),

$$u(1 - k)l_2 + vp'l_1 = l_1 l_2\left(\frac{k^2}{30} + p'k\right)$$

From (2),

$$x = D\,\frac{p'l_1 - (1 - k)l_2}{p'l_1 + (1 - k)l_2}$$

From (3),

$$y = l_1 l_2\left(\frac{k^2}{30} + p'k\right)\frac{1}{p'l_1 + (1 - k)l_2}$$

Let $l_1 = 100$ and $l_2 = 5$ or $l_1 = 20l_2$

Let D = 3 1-3 in. $= \frac{100}{30}$ on the 30th scale

Then,

$$x = \frac{10\,(20p' - 1 + k)}{3\,(20p' + 1 - k)}$$

$$y = \left(\frac{k^2}{30} + p'k\right)\frac{100}{20p' + 1 - k}$$

X and y are now in terms of p′ and k, two variables.

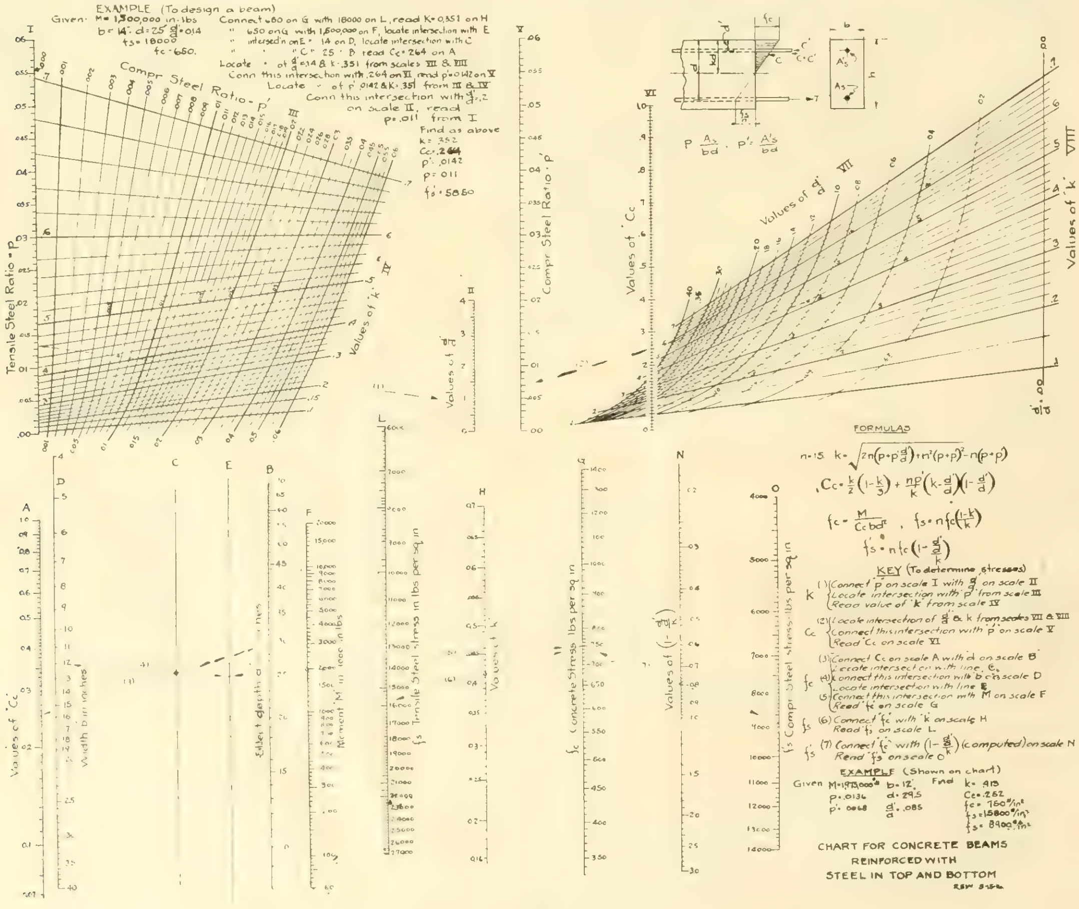


Fig. 4.—Chart for Reinforced Concrete Beams, Reinforced Top and Bottom.

(22)

First assume p′ constant, then compute x and y for different values of k. These points give, for the value of p′ assumed, an axis III, which will be graduated for values of k. Plotting axes for various values of p′ and connecting corresponding values of k by other axes give the network shown by axes III and IV.

Values of p are plotted on axis I and values of the ratio $\frac{d'}{d}$ on axis II. These scales are uniform as shown by the equations $u = l_1 p$ and $v = l_2 \frac{d'}{d}$.

Equation (19) is solved by the nomograph in the upper right-hand corner. It is plotted in the same manner as the one just described. The nomographs in the lower half of the chart are made by writing equations (20), (21) and (22) by means of logarithms and preceding as in the chart shown in Fig. 3.

The example on the chart under the heading, to determine stresses, is one such as might occur in investigating the stresses in a T-beam at the column or support, where the reinforcement, moment and dimensions have been determined by the design of the T-beam. The other example is one for design where dimensions, moment and fiber stresses are known.

This chart can be used for beams without compressive reinforcement by taking p′ and $\frac{d'}{d}$ equal to zero. For example, let $M = 1{,}000{,}000$ in.-lbs., $d = 25$, $b = 14$ and $f_c = 650$. Find $C_c = 0.176$ as in the previous example. Then connect $p' = 0.00$ on V with $C_c = 0.176$ on VI and read $k = 0.41$ on the line $\frac{d'}{d} = 0.00$ from VII. Find $p = 0.0094$ from I. Connect 650 on G with 0.41 on H and read $f_s = 14{,}000$ on L.

Charts of this kind are easily read by means of a triangle, or other straight edge, and a pointed pencil. In most cases this operation may be made continuous, like that of the slide-rule, until the quantity is obtained.

The charts herein described were made to a large scale and reduced by photostatic process to a convenient size.

OUTSIDE TEMPLATE FOR BUILDING LACKAWANNA STEEL SHEET PILE COFFERDAMS.

The outside template shown in the illustrations was built by F. P. Kemon, superintendent for the contractor, and was used repeatedly in setting up and guiding the new Lackawanna steel sheet piling for 12 single wall cofferdams required in constructing the piers for the Susquehanna River bridge recently completed for the Philadelphia & Reading R. R. at Milton, Pa.

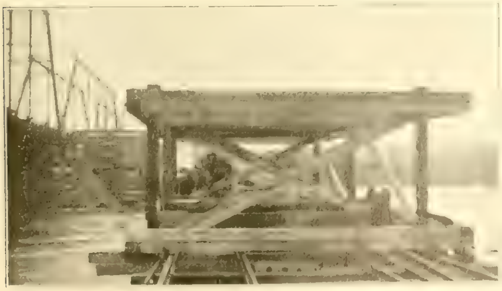


Fig. 1—Template Being Erected on Service Trestle

The new bridge was built parallel to and directly above the old bridge. Great quantities of large riprap stone, placed in the river by the railroad company as a protection to the old bridge from floods, ice and drift wood that pass out in great quantities in the spring of the year, were encountered on the bed of the river. This condition made it difficult to set the steel sheet piling plumb and true to line in the 8 to 15 ft. of water before driving and consequently the template was devised.

This template was an ouside frame of timber 6 in. larger all around than the cofferdam frame and shoring. It was built on the service trestle, as shown in Fig. 1, and set in the river with a 30-ton McMyler locomotive crane.

The templet not only made it possible to set up and drive the steel sheet piling plumb and true to line, but it also furnished a good foundation for working platforms for the workmen in setting the steel sheet piling up in place. The use of the template also prevented the steel sheet piling from being warped and facilitated pulling it out when the work was finished.

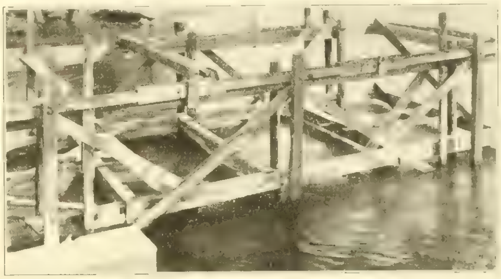


Fig. 2—Template in Place in River Ready for Piling.

After all the steel sheet piling had been driven, the template was removed by the locomotive crane and set in the river at the next pier site. The one frame was used successively on all 12 cofferdams. Figures 2 and 3 show the steel sheet piling and templates in the river before and after the piling is in place.

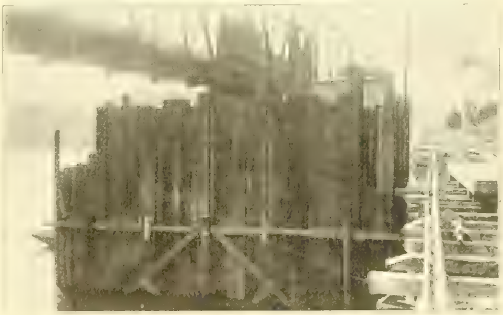


Fig. 3—Steel Sheet Piling in Place for Cofferdam.

Fifteen-in. arch web steel sheet piling 30 ft. long was boulders to bed rock, on which the piers for the bridge were built. Plans for bridge were drawn by Carl Dillenbeck, Engineer of Bridges for the Philadelphia & Reading R. R., of which Samuel Wagner is Chief Engineer. The contract for the bridge was executed by the Robt. Grace Contracting Co. of Pittsburgh, Pa.

The New York State Bridge and Terminal Commission has asked the Legislature for an additional appropriation to continue its work. The Commission, in a partial report, advocates the construction of either a bridge or a tunnel through which vehicles may pass between Manhattan, New York City and New Jersey.

Mr. George R. Dyer is Chairman of the Commission. The other members are Bridge Commissioner F. J. H. Kracke, former Dock Commissioner McDougall Hawkes, Mr. E. W. Bloomingdale and Mr. A. J. Shamberg. The New Jersey members of the Commission are Mr. W. H. Noyes, Chairman; Mr. J. Hollis Wells, Mr. DeWitt Van Buskirk, Mr. George Limouze and Mr. John J. O'Leary.

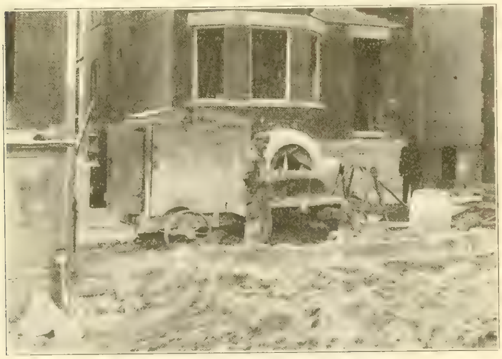
CONCRETE MIXER FOR MIXING MORTAR.

Many building contractors have adopted the practice of using a concrete mixer for mixing both the concrete for the foundation walls and the mortar for the bricklayers and the plasterers. The methods employed by E. J. Panos, a Chicago contractor specializing in the erection of houses and small apartment buildings, are as follows:

All foundations and basements are constructed first, using sectional wood forms and mixing the concrete with a machine. For mixing the mortar for brickwork and plastering he uses the same mixer employed for mixing the concrete for the foundations. The mortar box is placed on the ground about 15 ft. from the charging side of the mixer. A preliminary mix is given the mortar in the mortar box and it is then shoveled on boards by the side of the mixer. Sufficient mortar to last one or two days is usually given the preliminary mix at one time. The final mixing is done in the machine, and two men are able to turn out enough mortar in half an hour to supply 15 bricklayers for half a day. The usual practice is to mix enough in the morning to last until noon and immediately after the noon hour mix the additional quantity required during the afternoon.

This contractor uses a 10-cu. ft. Standard low charging mixer in all of his building operations. The mortar is discharged on boards placed on the ground, from which the hodcarriers shovel it into their hods as required.

The accompanying illustration shows the machine mixing mortar on one of the jobs of this contractor, located on Harding Ave. and 31st St., Chicago. The view showing the charging side illustrates the sand in the foreground, beyond which is the mortar box from which the preliminary mixed mortar is shoveled upon boards by the side of the mixer in most convenient location for charging.



Concrete Mixer Used in Mixing Mortar.

The daily economy of mixing mortar for 15 bricklayers with the machine as compared with mixing by hand is estimated by Mr. Panos as follows: Owing to the more thorough mixing of the machine, 1 bbl. less lime is required for each box of mortar. It requires but one hour a day for two men to mix enough mortar with the machine to last the bricklayers the entire day, whereas the entire time of two men is needed to perform the mixing by hand. On account of the very thorough mixing of the machine, no time of the bricklayers is required in tempering the mortar, which is figured as a saving of one hour a day for each bricklayer. At present prices this is estimated at a total saving of $18 a day. There is also an advantage in cold weather of being able to mix the mortar dryer with the machine than is possible when mixed by hand.

FRICTION OF BRONZE ON BRONZE.

Few experiments have been made to determine the coefficient of friction of bronze on bronze under high pressures. As a result much difference of opinion exists among designing engineers as to the proper value to give this coefficient when estimating the power required in the operating mechanism for large high-pressure sluice gates.

Experiments have been made during the past year by the U. S. Reclamation Service on the slide gates at the Pathfinder, Arrowrock and Elephant Butte Dams to ascertain the value of this coefficient. The results of these tests are given in the January Reclamation Record, from which the matter in this note is taken. The gates are provided with cast bronze bearing surfaces of the following chemical composition:

Item.	Copper. Per cent.	Lead. Per cent.	Tin. Per cent.	Zinc. Per cent.
Gate leaves	82.8	8.0	4.4	4.8
Gate seats	82.7	4.9	5.3	7.1

The gates are operated by oil pressure on pistons moving in cylinders mounted on the gate bodies. In making the tests pressure gauges were placed at the top and bottom of these cylinders, and the operating force was determined from reading these gauges. Internal friction of moving apparatus was approximated by the oil pressure necessary to move the gate near its wide-open position. The weight of moving parts was known and allowed for. The gates were moved so slowly that no correction for momentum was necessary.

Pressures were observed and frictional resistances were determined for the gates in various positions from closure to full open. With few exceptions, smaller friction factors were found with the gates partly open. This was probably due to vibration in the gate leaf, and the results obtained were apparently not reliable except for the position near closure. The results obtained in tests on two gates at Pathfinder, five at Arrowrock and two at Elephant Butte, all in practically closed position, are as follows:

Item.	Pathfinder.	Arrowrock.	Elephant Butte.
Size of gates (larger dimension vertical), ft.	4.42 by 7.5	5 by 5	3.92 by 5
Head on center of gates, ft.	127	48.5 to 54.8	107.3
Average time of opening, minutes	16	10	5.2
Average time of closing, minutes	14	11	4.2
Friction coefficient:			
Average for opening stroke	0.42	0.31	0.336
Maximum for opening stroke	0.44	0.42	0.383
Average for closing stroke	0.29	0.29	0.254
Maximum for closing stroke	0.31	0.34	0.268

The gates tested had been operated previous to the experiment at intervals of not over two months.

PERSONALS.

Charles Lawrence has been appointed city engineer of Warren, O.

Harry F. Harris, for the past 13 years a member of the city engineers' staff of Trenton, N. J., has been appointed county engineer of Mercer County, N. J.

J. C. Parker and E. T. Mock have opened offices in the National Realty Bldg., Tacoma, Wash., under the firm name of Parker & Mock, and will engage in an engineering and architectural practice.

John W. Reid, for the past 17 years connected with office of the city engineer of Detroit, Mich., has been appointed engineer in charge of the newly created Grade Inspection Bureau, of the Department of Public Works of Detroit.

L. T. Putnam, chief engineer of the Christopher Mining Co., and C. B. Mautz, formerly assistant engineer of the Chicago & Eastern Illinois R. R., have entered into a partnership under the firm name of Putnam & Mautz, with offices at Benton, Ill.

Farley Gannett has announced that his consulting practice will be conducted hereafter under the firm name of Gannett, Seelye & Fleming. Mr. Seelye has been associated with Mr. Gannett since Aug. 1, 1915, and Mr. Fleming has been associated since February, 1916. The offices of the firm will be at 204 Locust St., Harrisburg, Pa.

Frederic J. Herring of Little Rock, Ark., and Harrison Schellhous of Chicago have opened an office at Forrest City, Ark., for general civil engineering practice. Both Mr. Herring and Mr. Schellhous are graduates of Purdue University. Mr. Herring has held positions with the Bates & Rodgers Construction Co. of Chicago, the Columbia Steel Co. of Johnstown, Pa., and the American Sheet & Steel Plate Co. at Gary, Ind. Since coming to Arkansas four years ago he has been engaged chiefly in road and pavement construction. During the past year he was an assistant engineer with the State Highway Department. Mr. Schellhous has held responsible positions with the Monon R. R., was construction engineer for the People's Light & Power Co. in Southern Michigan, was in the employ of the Cook County, Ill., Highway Department and until recently was chief engineer of the Lafayette & Northwestern R. R.

INDUSTRIAL NOTES.

The B. F. Goodrich Co., Akron, O., has begun the distribution of its 5th annual issue of "Motor Trucks of America." The new volume contains more than 160 pages and is much larger than any of its predecessors. The introductory article in the 1917 volume is of especial interest to motor truck owners, for it deals at length with that ever important problem of lengthening the life of the motor truck.

The annual convention of the sales and factory organizations of the Chicago Pneumatic Tool Co., was held at the Great Northern Hotel, Chicago, on Jan. 11th, 12th and 13th. The program included a trip to the company's plant at Chicago Heights, concluding with a banquet at the Great Northern on Saturday evening. About 100 of the company's branch managers and representatives were in attendance. Dec. 31st closed the biggest month and the biggest year in the history of the Chicago Pneumatic Tool Co.

Planning and Management Quarterly Issue
of

Engineering and Contracting

Halbert P. Gillette, *President and Editor.*
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Volume XLVII. CHICAGO, ILL., JANUARY 31, 1917. Number 5.

ANNOUNCEMENT OF A SERIES OF ARTICLES ON LOGIC FOR ENGINEERS.

There is no particular reason why a logic for engineers should differ from a logic for business men, or indeed for any other class, except this—the terms used and the illustrations given may be better adapted to the understanding of engineers if they are presented by an engineer.

But is logic an engineering topic? To which we counter by asking: Is the application of science an engineering topic? Logic as it has been taught has lacked interest for engineers, mainly because it has not been expounded in a scientific manner. Fathered by Aristotle before there was any science save mathematics, the logic of the schools has remained largely a sort of glorified grammar, a system of language used in reasoning. Even so it would have been an excellent study for engineers had they thus been properly taught language as a tool for reasoning. But, unfortunately, the logicians have lacked ability to convey more than a moiety of useful instruction even on this matter of language as a tool.

The editor of Engineering and Contracting has made the study of logic his chief concern during "odd hours" for many years, and he has decided to present some of the results of this study in a series of articles, the first of which appears in this issue. The titles of the leading articles of the series will be:

I. Energy and Cause—Effect.
II. Classification and Identification by Class Characteristics.
III. The Three Processes of Thought: Induction, Deduction and Invention.
IV. Quantitative Distinguished from Qualitative Reasoning.
V. Language as a Tool for Reasoning.

These five leading articles will appear in successive numbers of the Planning and Management Quarterly issues of Engineering and Contracting. In addition there will be at least an equal number of minor articles on logic and its application published in issues intermediate between the quarterly issues.

DEFINITIONS OF SOME ECONOMIC TERMS AND COMMENT THEREON.

If one turns to current works on political economics for definitions of economic terms, it is found that many words are not defined at all and that others are incompletely or incorrectly defined.

Prof. Fisher in "The Rate of Interest" excludes interest from cost. He says (page 50):

> Even to those who do not formally accept any cost theory of interest the interest itself will seem in some sense to be a cost, and in most books an economic interest, however explained, is regarded as one of the costs of production. It is true that for a debtor who pays interest the interest is, to him, a real cost, and is so entered on his books. But we need only to be reminded of debit and credit bookkeeping which was considered at length in "The Nature of Capital and Income," to see that this item is counterbalanced on the books of the creditor, to whom the interest is by no means a cost, but an income. For society as a whole, therefore, even in the case of interest which is explicitly paid, it cannot be said that it constitutes a cost of production.

But what is "cost to society as a whole"? This is one of those seemingly self-defined expressions that really has no definition consistent with the ordinary meaning of the term cost. A cost is a payment or an obligation to pay for goods or services. It therefore involves a transaction between two parties. "Society as a whole" can not incur any costs at all, if we consider society as a unit. Interest is not a cost to "society as a whole"; neither are wages, materials or supplies a "cost to society as a whole." Fisher attempts to eliminate interest as a cost item, because to one man it is a cost while to another it is an income; yet this is true of every other item entered on a ledger. So that Prof. Fisher proves too much, or he proves inadvertently that cost has no meaning at all in relation to "society as a whole." Curiously enough he inferentially admits this fact in another part of his book, for he says (page 139):

> Society as a whole cannot borrow and lend, nor buy and sell

Well, if society can not buy how can it incur any costs whatsoever?

Prof. Fisher's confused ideas about economics are nowhere better illustrated than in his definitions, if we except his frequent omission to define important terms that he uses.

We purpose giving, from time to time, definitions of all the leading terms used in political and industrial economics, together with a brief explanation of each. The following definitions relate to price, value, cost, profit and interest:

Price Defined.—Price is the quantity of money exchanged for a given quantity of goods or services. Unit price is the price per unit of goods or services; e. g., $20 per ton, 30 ct. per man-hour, $7 per cu. yd., 5 ct. per kilowatt-hour.

Value Defined.—Value is a term used by the older political economists to denote the number of units of one class of goods or services, A, that can be exchanged for a given unit or number of units of another class of goods or services, B. Thus the value of an ox may be ten sheep. Some recent political economists define value to be synonymous with price. In spite of varying definitions, the word value always conotes intrinsic worth. The price paid for a thing is often said to be more or less than its value, meaning that the value is the normal price at which the thing would sell were both parties to the exchange possessed of full knowledge of all the market conditions and at the same time were neither party under abnormal necessity or compulsion. It seems preferable to restrict the term value to mean normal exchange price or intrinsic worth. This restriction of the term value also brings it into harmony with its derivative terms, "valuation" and "evaluate," which connote fair, or normal conditions of pricing.

The term "market value" should be used, if used at all, to denote price.

Cost Defined.—Cost has two meanings, one quite elementary and the other more complex.

In its elementary sense, the cost of a thing to a given owner is the sum of the prices, or total price, paid or payable by that owner at the time the thing was acquired. This may be called "elementary cost."

In its broader sense, the cost of a thing to a given owner at a given time is the sum of all net debits chargeable to the thing up to the given time including the value of the owner's time. This cost may be said to be "economic cost," in order to distinguish it from "elementary cost."

Elementary cost differs from economic cost in that it does not include "sacrifice costs."

Sacrifice cost is the payment (interest, supervisory wages, depreciation annuity and risk insurance) foregone during the period that a business is being developed or built up to a point where it earns a normal return on the investment. Sacrifice cost may therefore include interest during construction as well as its sequel, development cost or accumulated deficit in fair return on the investment.

Profit Defined.—Profit is the excess of selling price over cost.

We have just seen that "cost" is sometimes used in a sense that does not include "sacrifice cost." When so used, "profit" includes "sacrifice costs," such as proprietary supervision and interest on the proprietor's capital. There is no unanimity of practice respecting the use of the word profit, for obviously its significance depends upon the definition of the word cost.

The present tendency is to include in cost a charge for the proprietor's time as well as rental on his real estate and interest on his other capital and development cost. Then profit covers only the income that constitutes a reward for superior judgment, management, luck and insurance against risks and depreciation not included in the operating expenses.

Where the word profit occurs in a law or in a contract, it is evidently possible for dispute to arise unless the word cost is very fully and carefully defined.

Interest Defined.—Interest is the payment for the use of money. The payment for the use of real estate is rent, but the term rent is often applied also to payment for the use of other sorts of capital except money.

Interest includes not only a return for the use of money but insurance against risk and compensation for at least some proprietary supervision. Interest may also include compensation for taxes paid on money loaned.

Economists assign a single cause for the payment of interest, namely, the preference of present goods to future goods. Although this is the immediate cause of interest, the statement of desire as a cause is merely a platitude that yields no deeper insight into the phenomenon than was already had. We must look back to the mediate or remote causes. There are many motives that lead to borrowing and the consequent payment of interest. The most common motive in the present age is the desire to command labor and through successful command to secure profit.

Interest has thus become a device for selecting the highest officers of the industrial armies. Therefore it has proved to be an economic instrument of much greater efficiency than election, appointment, examination or other device used to select leaders. Therefore when socialists urge the abolition of interest through national ownership of all capital, they are coincidently contending that industrial leaders may be more effectively chosen in the absence of a system involving interest. This is a very broad claim and one that remains to be proved by trial. Certainly mere words can not prove it.

A BOOK ON A POLITICAL ECONOMIC SUBJECT BY A GREAT ENGINEER.

Herbert Spencer, the English philosopher, set a good example for engineers when, nearly 70 years ago, he began to write on social and political subjects. Until within the past decade relatively few engineers have followed his illustrious footsteps, but more and more frequently the world is hearing from engineers on social economic matters. The most recent notable utterance of this kind from an engineer is "America and the New Epoch," a 228-page book by Charles P. Steinmetz, "the wizard of the General Electric Company."

This book is probably destined to have a marked effect on public opinion relative to competition, for it comes from an engineer who has had exceptional opportunity to judge the effects of free competition as contrasted with co-operative effort. Mr. Steinmetz is a socialist. He sees in the great war a conflict "between the individualistic era of the past and the co-operative era of the future." Whatever the military outcome of the conflict, he predicts victory for the co-operative idea.

Germany's industrial rise is attributed by him to the adoption of socialistic or co-operative principles, and England's decadence to adherence to individualistic or competitive principles. But he recognizes that America has grown industrially in spite of competitive conditions. This he attributes partly to America's natural resources and partly to technical education.

The causes at work in fashioning the progress or decline of any nation are numerous, and an author may be pardoned for not attempting even to name them all. But it seems to us that Mr. Steinmetz should have cited a fact that the war has served to emphasize, namely, that the labor unions in England had greatly restricted the output of workmen of nearly every class. This is a fact of marked significance, one certainly that cannot be omitted from a cause-effect study of the kind that Mr. Steinmetz has made.

The "new epoch" in America, as Mr. Steinmetz views it in the coming, is to involve a greater and greater amalgamation of competing industries, evolving eventually into an "Industrial Senate." This political body will manage the affairs of every industry, eliminate competition, fix prices and wages, and, in short, be a sort of super-board of directors of all industry. Men will secure positions in this national organization of industry much as they secure them now in ordinary corporations, through merit; and the public in general will have no voice in their selection. There will be, however, a popularly elected body, representatives of the people, who will have the power of "veto to stop any action of the industrial senate which is against the public's interest."

We commend to every engineer this very interesting book—"America and the New Epoch."

ECONOMICS A QUANTITATIVE SCIENCE.

Bare words have never solved any problem in economics.

Qualitative language alone can not demonstrate a geometric "pons asinorum," $H^2\ P^3 + B^2$, nor can it prove that the "merits" of asphalt exceed those of macadam under stated conditions.

Every economic question is at bottom a question of costs or profits, and therefore a quantitative problem. When, therefore, two men are found engaged in controversy over the respective "merits" of two things, yet giving no specific numerical data, it may be inferred that neither of them possesses real proof of the soundness of his contention.

The typical political economist claims to understand the economics of government, but note carefully the significance of the fact that he confines most of his talk to "general principles." Old General Principles commands a vast army of ignorance. You will find him in supreme authority in nearly all books on political economy, ancient or modern, from Adam Smith to Taussig or Fisher. Note how rarely such authors give data and how profusely they utter opinions.

A business man who had listened for an hour to a professor of political economy rose with a sigh. "That man evidently talked himself into his present job," he said, "but if he were looking for work from me he would talk himself out of it in about ten minutes."

The ancient Greeks were great disputants. Given a knowledge of rhetoric, combined with ready wit, and any Greek was armored "cap a pied" for conflict with other knights of the long tongue. The spiritual descendants of these same linguistic jousters may be heard any day in councilmanic meetings, or in the hall of congress, vainly trying to solve the economic problems of city or nation by deftly debating pros and cons. Picture the directors of a great commercial or manufacturing company acting continuously in such futile fashion!

Even engineers, in spite of the fact that their training is more largely in economics than that of any other profession, may frequently be heard in wordy debate over economic questions.

Isn't it generally noticeable that economic wisdom is inversely proportional to the number of words used in economic argument? Words must be used to state an economic problem, to direct and guide the thought upon it and thus to assist in its solution, but the solution is never attained until numerical data are applied. But, queries an objector, what if we have no reliable data? Shut up and search, stop talking and start experimenting.

THE LIMITATIONS OF PERSONAL EXPERIENCE.

While all knowledge is founded on experience of one sort or another, it is a mistake to presume that success comes only to men of long personal experience. There are many striking instances of phenomenal success where the personal experience of the successful man was small. So frequently has this occurred that one might well infer that too much personal experience in a given line is a handicap rather than a help. However, it is perhaps more correct to ascribe the success of the inexperienced man to his superior inventive power. Yet even such an explanation carries with it an implication that invention is trammeled where precedent arising from personal experience has been long established.

Herbert Spencer congratulated himself that he had never received a formal education. He felt that his mind might have been trained too well to do the prescribed thing; and thus he might have formed the bad habit of never being wrong because of never departing from accepted practice. However much one may doubt the benumbing influence of any set training upon such an original mind as his, we may well ask ourselves whether there is not much to be learned from those who contend that great skill in performance of a given sort of act is bought at the expense of inability to originate a better way of achieving the same result.

If we may judge from things published, there are not a few very successful farmers who never farmed a foot of soil until past middle age. This may not be true, yet it is universally conceded that the great progress in American agriculture is mainly attributable to men at whom the farmers once laughed—professors of agriculture and scientists without so-called practical experience.

EDITORIAL COMMENT.

According to Mr. Guy E. Tripp, chairman of the board of the Westinghouse Electric and Manufacturing Co., his company last year expended more than $1,000,000 in research and development of new machinery and apparatus. This is exclusive of the cost of commercial development of new products to a profitable stage after they were placed on the market. The three great electrical manufacturing companies—Westinghouse, General Electric and Western Electric—are teaching American manufacturers a remarkable lesson in the value of scientific research.

Mr. Frank A. Vanderlip, president of the National City Bank of New York, said at a recent convention of a school of finance for business executives: "I believe we are a nation of economic illiterates. There is a science of business. It is something teachable." Yet a few years ago when engineers began to say that there is a science of management and that it is teachable, the scoffers almost drowned the announcement with laughter. There were then no bank presidents rising to champion the cause of business science. "Science, indeed!" they exclaimed. "You can't teach management. Managers are born, not made." Now it is admitted that managers are first born and then made.

SOME PRINCIPLES OF LOGIC FOR ENGINEERS.
I. ENERGY AND CAUSE—EFFECT.

By Halbert P. Gillette.

Logic.—Logic is commonly called the science of correct reasoning. I believe it should be regarded as that plus something more, namely, the science of creative or inventive reasoning. It is true that such authorities as Mill deny to logic the province of creative reasoning, but I fail to agree with the argument that inventive thinking can not be reduced to a system; and if it can be systematized at all it becomes scientific and therefore a part of logic. In this article I will not enter upon a discussion of what may be termed the logic of creative reasoning, but will confine myself to the subject matter of reasoning and some of the general principles relating thereto.

Energy, the Subject of Reasoning.—To a scientifically trained man like an engineer, it is not difficult to show that all reasoning relates to energy in some of its manifestations or its three categories—time, space and mass. Once this fact is firmly apprehended the first great step is taken toward an understanding of the principles of logic. The main defect in all books on logic is to be found in the failure to take this first great step.

Energy is what? Something in motion. Even so-called potential energy is a manifestation of the motion of an invisible something. Matter is probably composed of uniform particles that may be called corpuscles. Every variation in matter is, then, nothing more than variation in the grouping and motion of these corpuscles. Similarly, light, electricity, magnetism and other phenomena are corpuscular motions.

The mysterious energy that we call gravitation is probably a bombardment of the free corpuscles, called ether, upon bound corpuscles called matter. Since every particle of matter "shades" every other particle of matter from this bombardment, we have the phenomenon of universal mass attraction, and the quantitative fact that the attraction varies inversely as the square of the separating distance between mass centers and directly as the product of the masses.

Similarly such phenomena as elasticity, chemical affinity, etc., are all hypothetically explainable as manifestations of corpuscular bombardments of different sorts.

The fact that the atomic weights of many elements are even multiples of the weight of hydrogen was itself enough to create a strong presumption in favor of the hypothesis that all elements are composed of the same ultimate form of matter. But when Meyer and Mendeleeff discovered their "periodic law" relating to atomic weights and chemical characteristics of the elements, the hypothesis of ultimate uniformity of matter became almost irresistible. I was so impressed by this "periodic law" that about fourteen years ago I set about the task of ascertaining whether or not each atom has a definite "atomic heat of combination," as I termed it. I found that for simple chemical combinations I was able to prove this to be a fact ("Investigations in Thermal Chemistry Showing Atomic Heat Valency," Trans. Am. Inst. Min. E., vol. 34, year 1904), and that the heat given off upon chemical union of atoms with acid radicals is the sum of a constant atomic heat and a constant acid radical heat.

Many other facts could be cited in support of the hypothesis of the ultimate uniformity of matter and of the corpuscular character of every phenomenon. Indeed the very fact that energy changes its "form" in endless ways is alone strong evidence that every change is simply a corpuscular change. Perhaps the most broad generalization relating to matter and energy is this:

Every change in the universe is a change in the grouping or motion, or both, of corpuscles, while the total number of corpuscles in the universe and their aggregate energy remains constant or unchanged.

Part of this generalization obviously states the well known law of "conservation of energy"; but the whole generalization must be apprehended before a philosophic understanding of things is possible.

It may well be asked what significance a generalization of this character has in connection with the study of logic. The reply is that all reasoning relates to energy, and that every sound rule or principle of reasoning must ultimately find expression in terms of energy. Every significant word is a symbol or part of a symbol of energy or its categories. Every significant proposition is a group of words that "picture" energy or the categories of energy. This being true, we are able to generalize a test of the significance of words and propositions:

Words or groups of words that cannot be translated into terms expressing energy or its categories are meaningless, and those that are not consistent with energy manifestations are false.

By the application of this test it will be found that nearly all the "reasoning" in books on metaphysics, such as Kant's "Critique of Pure Reason," is merely a juggling with terms that are meaningless, although they bear the semblence of rationality. Thus Kant uses the word "transcendent" to denote knowledge that transcends experience. A true definition of "experience" in terms of energy makes evident at once that the word "transcendent," as used by Kant, has no meaning at all.

Experience is an arrangement of the atoms of the brain by the interaction of external energies with the energies of the nerve-stuff. Experience is both inherited and individually acquired. It is individually acquired experience that is commonly called experience, though, in fact, individual experience is indistinguishable in general character from inherited experience. Knowledge is itself experience. Hence there can be no form of knowledge that transcends experience, or is "given from the beginning."

If the reader cares to gain skill in the discovery of fallacies, he will do well to apply the above given method of attack to the reasoning of Kant and other so-called philosophers of the metaphysical schools. Bergson's recent work on "Creative Evolution" is an admirable target. Try it.

Energy-Groups.—The simple groups of corpuscles that form the atoms, or elemental energy-groups, combine to form more complex energy-groups called molecules. These, in turn, form aggregates or colonies of energy-groups, most of which are inorganic and a few of which are animate. The common word "matter" is applicable to all such energy-groups. Matter consists of "bound" corpuscles.

Pervading the universe there are "free" corpuscles moving in every direction with the velocity of light, than which no velocity is or can be greater. These "free corpuscles" constitute what is called the ether. When some of them move in waves of a definite sort, there result certain phenomena—light, or radiant heat, or electricity, depending on the character of the wave. It has been demonstrated that the bombardment of corpuscles in the "form" of light produces a pressure upon a surface from which light is reflected.

Let us call light, radiant heat and electricity by the general term etherial-energy-groups, to distinguish them from material-energy-groups. This distinction, however, does not imply that one of these two classes of energy-groups comes into existence independently of the other. Light, heat and electricity are undoubtedly resultants of certain vibrations of atoms. The fact that every highly heated atom has its individual spectrum lines, differing from every other atom, is evidence that light is the result of vibration of the corpuscles of an atom.

Molar heat is a vibration of "bound" corpuscles, or atomic-corpuscles. Molar heat, through its interaction with the "free" corpuscles or ether, causes radiant heat and light.

Cause and Effect.—If what has preceded is true, cause and effect must be names for energy. A little study makes it apparent that causes are energy-groups prior to an interaction, and that effects are other energy-groups subsequent to that interaction. In other words, the instant prior to an impact between two or more different groups of corpuscles, the energy-groups are causes; while the instant following the impact the changed energy-groups are effects. This conception will greatly clarify all reasoning relating to cause-effect.

In Mill's "Logic" the chapter on Causation is loaded with errors arising from his failure to have a proper conception of the "essence" of what is a cause and what is an effect. He saw quite clearly that there must always be more than one cause—that the word cause is philosophically a plural word though it has a singular form. But he failed to see that the same holds true of the word effect.

There can never be a single cause or a single effect.

We can, of course, focus our attention on one of the several causes of a phenomenon, and we may focus our attention on one of the several effects, but we should never forget that there are two or more energy-groups involved in every change, both before and after the instant of change.

A succession of changes may occur so rapidly that the true reactions are not perceived and there may be some unknown energy-group at work in some of the changes intermediate between the first and last. It is very important, therefore, to distinguish between immediate causes and mediate or remote causes.

One of the immediate causes of malaria is the germ that a mosquito inoculates into the body of a man. The mosquito is a remote cause, and the swamp is a still more remote cause. Long after swamps were recognized as causes of malaria the immediate cause, the germ, was discovered.

It was known for a long time that the conductivity of heat through a metal plate into water was such as to indicate some "skin resistance" to the passage of the heat from the metal surface, but it was not until recently that it became evident that an unrecognized cause had been obscuring the phenomenon, namely, the existence of a quiescent film of water on the surface of the metal. Similarly quiescent films of air and other gases adhere to all solids and affect the rate of heat transfer.

Invariability of Cause-Effect.—Heat is a form of energy that is generated by apparently different causes. Thus heat results from friction, from molar impact, from elastic deformation, from chemical action, etc. Such facts as this have puzzled many logicians, for if there are different causes of heat, for example, how can it be said that nature is invariable in her actions? Yet all science and indeed our ability to reason rest on the fact that like causes invariably produce like effects. In the case of heat the paradox vanishes when it is seen that heat invariably exists in every particle of matter, and that its quantity and degree of intensity are invariably increased by any sort of impact that increases the vibration of the atomic corpuscles. The immediate cause of increase in heat is an impact, and it matters not whether the impact be that of two atoms rushing into chemical union, or whether it be a hammer striking a nail.

Similarly electricity is a form of energy present in every particle of matter. Its quantity and degree of intensity are increased by seemingly different causes, but, as with heat, there can be no doubt that the immediate cause of every change in the intensity or quantity of electricity is precisely the same in every case.

Water is caused by the union of hydrogen and oxygen. These are its immediate causes, but since hydrogen exists in many chemical combinations it is possible to generate water from many different things. Thus water is produced when kerosene is burned, also the combustion of sugar, wood, etc., cause water to be formed. To one looking at the great variety of remote or mediate causes of water it might seem that water is an immediate effect of inumerable causes, whereas it is an immediate effect of hydrogen and oxygen and of no other elements.

The immediate effects of like immediate causes are invariably the same qualitatively and quantitatively.

By "like causes" I mean energy-groups that are precisely alike in class and in quantity of energy. This law may be expressed in many ways, all of the same significance, thus: Every entire cause invariably produces the same entire effect. Conversely, if there is any difference in the effect of seemingly like causes, the causes are not entirely alike.

A number of useful corollaries may be drawn from the preceding generalizations relative to cause-effect, among which are these:

1. Although no individual energy-group can cause itself, it may be one of the causes of another individual energy-group of the same class; e. g., a fire may be one of the causes of more fire.
2. Unlike complex causes lead to unlike complex effects but among which there may be individual effects that are alike; e. g., many kinds of disease are mediate causes of fever, but even so the immediate cause of the rise in temperature is the same.
3. One individual effect may be common to several different complex cause-effect groups, but other effects will differ.
4. Among several interacting causes none can be assigned a superior importance.
5. There is no exception to a truly general cause-effect law.
6. In a given complex energy-group there may be quantitative functional relationship between different parts, but this does not make one of these parts the cause of the other part; e. g., the hypothenuse is a function of the base and the perpendicular but causes neither of them.
7. In arriving at the cause of a given effect by a process of elimination, no individual energy-group associated in any manner with the production of the effect can be eliminated until evidence establishes its non-participation as a factor in changing the effect.

I can not attempt to illustrate each of these logical principles in this article. I may suggest, however, that the reader will profit by searching for examples of false reasoning illustrative of failure to apply these generalizations. To mention one book that is full of cause-effect sophistry I may name Fisher's treatise on "The Rate of Interest." In his effort to show that interest has only one general sort of cause, Prof. Fisher falls into more cause-effect errors than I have ever seen in any other monograph of its kind.

In the Quarterly Journal of Economics, Aug. 1914, Allyn A. Young, Professor of Economics at Cornell, attempts to prove that nothing should be deducted for accrued depreciation in arriving at a value for rate-making purposes. After a discussion that presumably establishes his proposition, he says: "There are many cases which these general assumptions (as to depreciated value) do not fit and for which our conclusions have to be correspondingly modified. * * * But the principle of such exceptions is simple."

If "general assumptions do not fit," how can they be general? After attempting to derive a scientifically general rule, Prof. Young destroys his whole argument by admitting that there are exceptions. There is no exception to a general scientific rule. Any exception proves its lack of generality, and consequently that all the concurring causes have not been fully ascertained.

"Progress and Poverty," by Henry George, contains a splendid collection of economic sophistries, many of which are readily disclosed by the application of the principles above given. Thus, George establishes (p. 154) that the cause of low wages is neither lack of capital nor niggardliness of nature. Hence, he reasons, the cause of low wages is not to be found in the laws that govern the production of wealth, and must therefore be sought in the laws governing its distribution. All of which sounds plausible until one asks: But have you named all the causes that affect wages? Then immediately it is seen that he has omitted scores of causes, such as degree of industrial education of workmen, freedom of personal contract, manner of payment for work done, character of government, extent of taxation, etc. Henry George omits all such conditions affecting wages, and by a false (because incomplete) process of exclusion, comes to a single cause of low wages—private ownership of land!

I have selected these few illustrations of cause-effect fallacies from the writings of political economists, because men of that class can not be charged either with lack of education or with failure to have studied their subject.

In the next article of this series the subject of classification and identification of energy-groups will be discussed. Throughout the entire series of articles logic will be treated as a study of the principles of energy applicable in systematic reasoning. Words and propositions will be discussed as energy-groups, themselves symbolic of other energy-groups. The processes of the mind will be shown to be analogous to mechanical and chemical processes with which we are quite familiar. In short, we shall come at every door in logic with the same key—energy—confident that it will open all of them.

MODERN METHODS OF PRECISE LEVELING BY THE U. S. COAST AND GEODETIC SURVEY.

Great improvements in method have been made during the past 20 years in the United States in determining by spirit leveling the difference in elevation between widely separated points. This may be said also of most other countries. But it is believed that for effort expended and the accuracy of the results the work in the United States is, at least, the equal of that of any other country. In a paper presented Dec. 29 before the Engineering Section of the American Association for the Advancement of Science, Mr. William Bowie, Chief Division of Geodesy, U. S. Coast and Geodetic Survey, describes the precise leveling method employed by that organization. Mr. Bowie's paper, practically in full, follows:

All engineers are familiar with wye or spirit leveling. But it is only in several of the government engineering organizations that the most accurate leveling has been done to any large extent, and today the government's activity in this line is almost exclusively confined to the U. S. Coast and Geodetic Survey.

In 1867 the International Geodetic Association defined precise leveling as that grade of leveling in which the probable accidental error is not more than ± 4 mm. per kilometer. This accuracy has been maintained in the United States in the precise leveling by the U. S. Coast and Geodetic Survey, the U. S. Army Engineers, the U. S. Geological Survey, the Pennsylvania and the Baltimore & Ohio Railroads and several other organizations.

Owing to the great advance in the excellence of precise leveling instruments and in the methods developed to eliminate the effect of unavoidable errors from the results, the International Geodetic Association defined another grade of leveling, called leveling of high precision. In this the probable accidental error shall be not greater than ± 1 mm. per kilometer, and the probable systematic error not more than ± 0.2 mm. per kilometer. Practically all of the leveling done by the Coast and Geodetic Survey since 1898 comes within the specifications of this higher grade.

A very severe test of the accuracy of leveling may be obtained from the closing errors of closed circuits. In the latest adjustment of the level net of the United States there were 26,707 miles (42,979 km.) of leveling involving 84 circuits.* The following table shows the corrections applied to the leveling lines which were necessary to close the circuits:

[illegible] in mm.	[illegible] in thousandths of foot	No. of lines.	No. [illegible]	No. miles.	Per cent of whole
[illegible]	0.00 to 0.52	56	17,251	10,719	40.1
0.10 to 0.20	0.52 to 1.05	[illegible]	8,708	5,411	20.3
0.20 to 0.30	1.05 to 1.57	[illegible]	[illegible]	[illegible]	[illegible]
0.30 to 0.40	1.57 to 2.10	[illegible]	1,480	920	[illegible]
[illegible]	2.10 to [illegible]	14	1,488	925	[illegible]
[illegible]	[illegible] 3.15	[illegible]	[illegible]	306	1.1
[illegible]	3.15 to 3.67	[illegible]	[illegible]	370	1.4
[illegible]	3.67 to 4.20	1	[illegible]	194	0.7
0.80 to 0.90	4.20 to 4.72	1	150	93	0.3
[illegible]	4.72 to [illegible]	[illegible]	647	462	1.5
1.00 to 2.00	5.25 to 10.50	13	[illegible]	1,290	[illegible]
[illegible]	[illegible] 10.50	1	48	30	0.1
Totals ..		..173	[illegible]	26,707	[illegible]

There are now in the United States (December, 1916), about 35,300 miles of precise leveling, with 90 closed circuits. The work done since the last general adjustment of the net is of a grade of accuracy equal to that of the work done just previous to the adjustment.

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* [illegible] Coast and Geodetic Survey, [illegible].

All of the leveling is run in duplicate, that is each section is leveled over in the forward and backward directions. If the two runnings of a section do not give the differences in elevation which agree within 4 mm. times the square root of the distance in kilometers, other runnings must be made until a satisfactory agreement is obtained.

The amount of extra running is usually less than 10 per cent. Except for blunders in rod readings, the allowable limit need seldom be exceeded. But the observer is striving for minimum unit costs and that he therefore endeavors to make the greatest progress by taking the maximum length of sight which atmospheric conditions will permit. The average discrepancy between the forward and backward runnings is about one-half the allowable limit.

The accumulated discrepancy between the forward and backward runnings of a long line is in general less than 0.2 mm. per kilometer.

In order to insure the requisite accuracy in precise leveling, the line is run at least twice, as stated above; the maximum sight is 150 meters (490 ft.); the back and foresights are made practically equal; the rods are accurately standardized for length, and corrections for erroneous lengths are applied; corrections are made for the expansion of the rods due to differences between the temperatures of the rods at the time of observing and the standard temperature; the collimation error of the level is kept within a certain allowable maximum, two rods and rodmen are used; at the odd numbered setups or stations the back rod is read first, and at the even numbered stations the foresight is read first, thus eliminating largely the effect of gradually increasing or decreasing vertical refraction; well seated spikes, holding the rails of the railroads over which the leveling is done, are used for the rod supports or turning points; the instrument is shielded from the wind and protected from the direct rays of the sun at all times, including moves between setups.

These are the essential factors in any precise leveling and leveling of high precision. In addition to these the Coast and Geodetic Survey has used, during the past 16 years, an instrument which further adds to the accuracy. It has frequently been described† so no space for a full description need be taken here. It is made largely of an alloy of nickel and iron with a coefficient of expansion about one-fourth that of steel. The level vial is set into the barrel of the telescope close to the line of sight. The final adjustment of the bubble before making a rod reading is made with a micrometer screw at the eye end of the telescope. The image of the bubble is reflected and refracted back to the left eye of the observer through a tube which is parallel to the telescope and the observer can see the bubble and the rod at the same instant.

The Survey is now using a rod which has the graduations painted on a strip of gamma steel (an alloy of nickel and steel) which has a coefficient of expansion of less than one-tenth that of steel. This strip is fastened rigidly to a metal foot, and the strip and foot are mounted on a white pine bar. The foot of the rod is a plane, 1⅛ in. in cross section, which is at right angles to the face of the rod. The strip is graduated to centimeters and the numbers indicating the decimeters and meters are painted at the sides of the strip, on the wooden bar.

The use of this rod by the Survey, and also the use of the railroad spikes for rod supports, were innovations during the past season. The results of these changes have been excellent as is shown by the agreements between the forward and backward readings, obtained by the several parties in the field. For this leveling the average accumulated difference between the two runnings is about 0.1 mm. per kilometer, or 0.005 foot per mile.

Much of the success obtained in leveling is due to the skill and judgment of the chief of party, who is also the observer. While the above account of the precautions taken to insure accuracy may appear to be intricate and cumbersome, yet the progress made by the precise leveling parties is truly remarkable. The average progress made by a single party in a month is about 100 miles (160 kilometers). When it is remembered that each mile is leveled twice with approximately 10 per cent of rerunning, it is seen that the actual running per month is about 220 miles.

The maximum progress was made in September, 1916, by the party of Mr. John H. Peters, in Michigan. The progress made was 159.6 miles (357 km.) and the number of miles of single running was 340. It is doubtful if such progress has ever been equalled even in the crudest kind of spirit leveling.

The great speed attained in precise leveling is made possible by the use of motor cars for transporting the party to and from the field and during actual leveling. These cars weigh about 350 lbs. each and can be run without danger at a speed of about 20 miles per hour. They may be taken off the track easily upon the approach of a train.

The tripod and level are now mounted on one of the cars. The instrument remains fastened to the car from the beginning to the end of a day's work. In spite of the jarring incident to moving between stations the instrument remains in excellent adjustment and no damage to it results. The observer stands close to the instrument, and in changing his position for the second sight he passes under the tripod.

It is readily realized that the work of the observer is greatly lightened by not having to carry the tripod and level between stations and in not having to set up the tripod at the new station. Leveling the instrument is very quickly done at the new station and especially when there has not been a material change in the grade of the road between stations. Nearly all the precise leveling by the Survey is done along railroads.

Another very important improvement made during the past season is in recording the rod readings on a listing adding machine, which is mounted on the second car. The back sights are listed in the left hand four columns and the foresights in the right hand four columns. The machine has nine columns and it adds to ten places. At the end of a section between bench marks the numbers listed are added in the ordinary way and the paper shows the sum of the back sights in the first five places and of the foresights in the other five. The two sets are subtracted mentally and the result is the difference in elevation between the two bench marks at the ends of the section. If each rod is read from three wires the result must be divided by three. A sample record is shown below:

SAMPLE LEVEL RECORD.

```
Q-21        915127                    124000000
                                      141200000
         216800000                    158800000
         234000000                         1572
         251000000                         1742
              1522                         1918
              1695                         1460
              1869                         1632
              1400                         1809
              1572                    141900000
              1747                    159000000
         160000000                    176200000
         177300000                    175900000
         194900000                    193100000
         105100000                    210500000
         122500000                         1091
         139900000                         1267
              1978                         1439
              2150                          510
              2321                          570
              1880                          630
              2052                    174900000
              2227                    181700000
          86500000                    186500000
         103900000
         121100000                   3936738053
```

Code numbers are used to indicate the weather conditions, the temperature of the rod, etc. Some of the notes must be written on the record by pen or pencil.

The former method of recording was to use a notebook which involved very much more work in the computation both in the field and at the office.

The average cost of precise leveling by the Coast and Geodetic Survey is now about $10 per completed mile or less than $5 per single mile of leveling. This cost includes the purchase and setting of permanent bench marks, about one for each two or three miles of the line, and all salaries and traveling expenses.

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†See especially Appendix 3, Coast and Geadetic Survey Report for 1903.

While so much depends upon accurate leveling in nearly all surveying and engineering work by the federal, state, county and municipal governments, by railroads and by individuals, it is hoped that the general practice in spirit-leveling will be radically improved. The costs of such work could be lowered by the use of what is called the precise level and rod and if at least some of the precise leveling methods were followed.

A plea is made for the general adoption, where practicable, of mean sea level datum, for then there would be uniformity and eventually all extensive systems of leveling in the nation would be properly correlated.

There are few cities today which have adopted the mean sea level as the official datum, but all will some time have to adopt this datum, as have Cincinnati, O.; Birmingham, Ala.; El Paso and Fort Worth, Tex., and some others. Even in Washington there are three datums in use for surveying and engineering operations. This is not efficiency and while the cost of changing all records to the ideal datum will in any case be heavy, yet in the years to come far greater savings will result from making the change.

The Coast and Geodetic Survey parties ran about 2,500 miles of precise leveling in 1916. The precise leveling net of the United States now comprises about 35,300 miles of lines, and the Survey is planning to have in the near future such an additional amount as will leave no place within the United States more than about 100 miles from a precise level bench mark. Late on the intermediate areas will be filled in by precise levelings as occasion requires.

The United States Geological Survey has many tens of thousands of miles of spirit leveling for the control of elevations for their topographic maps. All of the leveling of that organization is based on the precise leveling net and is consequently on the mean sea level datum. Practically all the leveling done in the interior of the country by the U. S. Army Engineers is also on sea level datum. But much of their local leveling done in connection with their harbor improvements is on low water datum.

NEW WIRE-DRAG EQUIPMENT.

Several new appliances have been used recently by the U. S. Coast and Geodetic Survey in its wire-drag work.

Galvanized stranded wire 3/16 in. in diameter, made into 100-ft. sections and joined by means of drop-forged swivels and special light sockets, was used for the first time on the west coast. It proved more satisfactory than the telephone wire formerly used, although it was parted several times in the strong tides of Snow Passage and Kashevarof Passage.

The new design of small buoy, which is nun shaped and larger and heavier than those formerly used, proved satisfactory. None of these buoys was lost through collapsing.

Metal floats were regularly used for the first time in wire-drag work. The floats were made of No. 18 galvanized sheet iron, riveted and soldered. They are made cylindrical with a cone at one end, a ring-bolt being inserted and soldered fast at the apex of the cone for attaching to the ground wire by means of a short line and snap hook. They cost about $1.80 each and are a great improvement over the wooden floats. Their buoyancy is constant and can be accurately gauged. Their use removes entirely one of the troublesome uncertainties connected with drag work, namely, the varying buoyancy of the wooden floats due to waterlogging.

Road Maps Protected by Celluloid Cover.—An eastern highway engineer uses a celluloid envelope for covering road maps. The cover is made from a piece of transparent celluloid twice the size of the map. The celluloid is folded into envelope form and three of its edges fastened together.

THE ADVANTAGES OF AN ENDLESS TAPE LEVELING ROD FOR PROFILE AND CROSS-SECTION WORK.

By Halbert P. Gillette.

Tweny-four years ago, when I had just entered upon the practice of engineering, I devised an endless tape leveling rod that enabled me to increase my daily output of work and to decrease errors. Sixteen years ago I described the rod in "Engineering News," and, following that article, it was claimed that the same sort of a rod had also been invented by Prof. J. B. Davis of the University of Michigan. Not long afterward an endless tape rod was put on the market by W. & L. E. Gurley of Troy, N. Y.

In spite of all the publicity that this type of rod has received during the last 16 years, I find that it remains unknown to most surveyors and that those who have heard of it have little knowledge of its real utility. It seems wise, therefore, to reprint here my original article on this rod, together with some additions and an illustration of its latest form (Fig. 1) from the Gurley catalog.

The rod shown in Fig. 1 has an endless steel tape, but the rod that I originally made (Figs. 2 to 5) had a wire-woven linen tape, which in many respects is preferable to steel. Although a linen tape stretches slightly with use, the error thus introduced is seldom of importance in profile leveling and is of no importance at all in cross-section leveling and slope-stake setting.

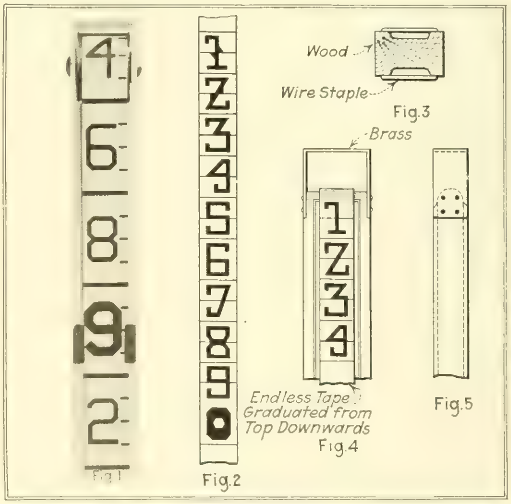


Fig. 1—Endless Tape Leveling Rod (Gurley). Figs. 2-5—Endless Tape Leveling Rod.

It will be noticed (Fig. 2) that the tape is graduated progressively from the top down. This order makes the rod an automatic adding and subtracting machine for profile or cross-section work, and eliminates several columns of figures in note books and the calculations involved in ascertaining elevations.

The rod is particularly adapted for slope-stake setting; for, used with a special slope-stake tape, the operation of locating the position for a slope-stake becomes entirely automatic, as will be explained.

First, I will describe how the rod shown in Figs. 2 to 5 was made.

Making the Rod.—The rod consists of a strip of white pine 1x2 in. x10 to 14 ft., dressed so as to leave a bead on each side, as shown in cross-section, Fig. 3. Passing around the rod lengthwise is a movable endless tape graduated from the top downward; that is, in exactly the opposite direction to the graduations of the common self-reading rod. The ends of the rod are rounded, as shown in the side view, Fig. 5, so that the tape will slip readily.

The tape should be 1 in. to 2 in. wide; but, as I was able to find no suitable tape in the market of this width, I made one by cutting an ordinary 100-ft. linen tape into three pieces, laying two of the pieces side by side, blank face down, and the third piece on top of the two. The third piece was then sewed by shoemaker onto the two pieces, the result being a tape 1¼ in. in width.

Stretch a section of this prepared tape, fastening it with thumb tacks to a table and graduate carefully in feet and tenths, marking with a pencil. Upon this tape stencil the feet and tenth figures, progressing from the top down. Stencils may be cut out of cardboard and the outlines marked on the tape with a pencil, afterward filling it with India ink. The block form of figures shown in Fig. 2 enables one to read to the .01 ft. The graduated tape is stretched around the rod with about the same tension used during the process of graduation and a mark is made where the tape is to be spliced; it is then taken off and a soft leather splice sewed on so as to make the tape continuous. To get the tape back onto the rod it is necessary to bend the rod slightly in the form of a bow and slip the tape over the ends. The tape is held in place by small wire staples that span the tape and are driven into the rod at intervals of about 2 ft. The ends of the rod are protected by U-shaped strips of brass, as shown in Figs. 3 and 5. It would seem that rollers should be provided at the ends of the rod upon which the tape would travel with ease, but I found them unnecessary. It might also seem desirable to provide some sort of a clamp to prevent the slipping of the tape after reading of the rod has been taken, but this likewise is not needed.

Profile Leveling with the Automatic Rod.—The automatic leveling rod is almost as useful for running a line of profile levels as for cross-sectioning, the operation of profile leveling being as follows:

Hold the rod on the B. M., whose elevation is, say, 127.32, and set the endless tape so that the last three figures, namely, 7.32, are read on the rod; then wherever the rod is held, the rod reading will give the elevation of the point upon which it is held by prefixing the first two figures of the bench mark, namely 12. In other words, the rod readings give the elevations of the ground or bench marks direct and without calculation.

When it is desired to move the level forward, take a rod reading on the turning point, say 1.24; move the level forward, set up, raise or lower the endless tape until the rod again reads 1.24 and proceed as before. It will be observed that the rod automatically adds or subtracts, thus relieving the instrument man of all mental labor; while the notes are kept entirely in one column which is at once the rod reading and ground elevation.

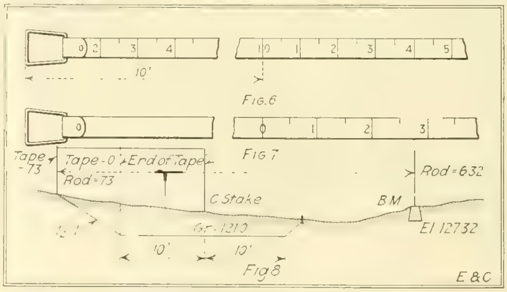
Engineers who are fond of harping upon the great exactness of their leveling will raise the objection that an automatic rod such as described will give results altogether too approximate. But it is seldom that grading closer than 0.05 to 0.1 ft. is required on any work; and for such purposes a rod read to hundredths on B. M.'s and tenths on the ground is sufficiently exact. For most purposes reading rods to thousandths on B. M.'s and hundredths on the ground is one of those absurd time-consuming practices with which I have no patience. It is observable that the engineer that reads to thousandths is the one that oftenest makes mistakes of feet.

It should be added that a satisfactory endless tape rod can be readily made by using the ordinary engineer's wire woven cotton tape, instead of one specially graduated as described. Such a rod can be read to the nearest tenth only, which, however, is close enough for ground readings, and a New York or Philadelphia rod must be used on turning points and bench marks, and is particularly suitable for hand-level work.

Setting Slope Stakes with the Automatic Rod.—To locate slope stake positions automatically with the endless tape rod, it is necessary to have a special slope stake tape. This may be made as follows:

Take any linen tape graduated in feet and tenths, and beginning at the zero end lay off on the tape half the width of the proposed roadbed. If the roadbed is to be 20 ft. wide, lay off 10 ft. on the tape, then turn the tape over and on its blank side and directly opposite the 10-ft. mark paint 0 with India ink. Beginning at this new 0 point make a series of marks 1.5 tenths apart, if the side slopes of cuts are to be 1.5 to 1; but, if the side slopes are 2 to 1, make the aforesaid graduation 2 tenths apart. Next paint over each mark its proper denomination, beginning at 0 and progressing exactly as any tape is graduated. Fig. 6 shows the front face of the ordinary engineer's linen tape. Fig. 7 shows the rear face of the same tape graduated as just described. The graduations need be carried out only as far as the probable distance of any slope stake from the base line.

The operation of setting slope stakes, using the tape and rod prepared as above described, is as follows: Assuming that slope-stake setting begins at Station 0, and the proposed Grade Elevation is 121.0, while the nearest Bench Mark elevation is 127.32, set up the level at a convenient place, as shown in Fig. 8, hold rod on B. M., and move the endless tape up or down until the rod reads the difference between the B. M. elevation and Grade Elevation, in this case 6.32. Next hold rod on ground at center stake at Station 0, the rod reading will give the center cut direct without further calculation. Next move the rod out to a point where it is estimated the slope stake should be set, and let us assume that the rod reading is 7.3. Measure with the specially prepared tape (shown in Fig. 7) from the center stake to the rod, holding the end of the tape at the stake. If the tape reads 7.3, the spot where the rod stands is exactly the right place for the slope stake; if, however, the tape reads, say 6.6, then move the rod a few tenths farther out and read rod and tape again, repeating the operation until the rod and the tape read exactly alike, and at that point drive the slope stake, making thereon the rod reading, which will be the cut.



Figs. 6 and 7—Method of Graduating Tape for Slope Staking. Fig. 8—Method of Using Automatic Rod and Tape in Cross Sectioning.

It will be seen that no calculations at all are involved in this method of slope-staking, except the preliminary calculation for the first rod reading, and that errors are practically impossible. Should the grade be +0.5 per cent from Station 0 onward, it will be necessary to move the tape down 0.5 ft. before taking the rod reading at Station 1, and a like amount at each succeeding station.

When a fill is encountered it becomes necessary to hold the rod upside down, both on B. M. and ground. This can be done by a careful leveler without error, since the figures on the rod are equally clear when reversed. If, however, it is feared that errors may be made, another rod should be constructed similar to the one described except that the figures should progress from the bottom upward; one rod being used for cuts, the other for fills.

It is obvious that cross-section leveling can be done with rapidity and accuracy, and that the cut or fill can be read directly on the rod if the grade has been established, thus saving all the computation that is ordinarily involved in this sort of work. If the grade has not been established, then the rod is used to read ground elevations direct, instead of reading cuts or fills.

Use of the Automatic Rod for Tracing Contours.—In topographic work involving the tracing of contours, either with a Y-level or a hand-level, the automatic rod will be found very useful. Particularly is this true where contours are to be closely spaced and accurately located. Using the stadia wires of a transit for determining distances, and using a hand level for determining elevations, contours can be located with accuracy and great rapidity. The long bubble of the transit should then be used at intervals to check the hand-level work.

Saving of Time Effected.—Unfortunately, my notes as to the saving in time effected by the use of this rod have been lost. I recall, however, that the speed of setting slope stakes was increased 50 per cent after the automatic rod and slope tape were put into use. And, as I remember it, a somewhat similar saving of time was effected in cross-section leveling, inclusive of the time previously spent in calculating ground elevations and thence deducing cuts and fills.

HOW TO MAKE YOUR OWN LOG TABLE.

Contributed by W. F. Schaphorst.*

This rough method of finding approximate logarithms is simple and very easily remembered:

Lay off axes A C and B C at right angles to each other. From the intersection lay off nine equal spaces to the left as shown and mark them 1, 2, 3......10 from left to right.

Then lay off ten equal spaces upward from the intersection as shown and mark them 0.1, 0.2, 0.3, etc. Then, with the extremes A and B as centers, and distance A B as the radius, locate center D. From that center describe the arc A B.

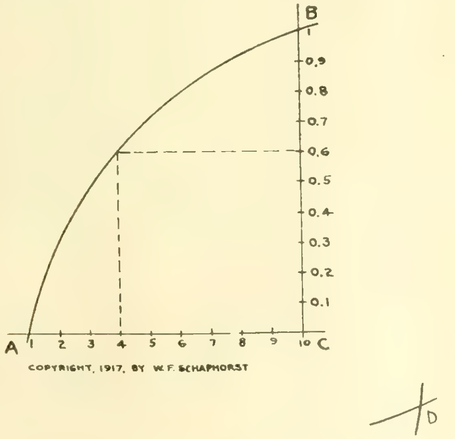


Diagram for Finding Approximate Logarithms.

We are now ready to read off our approximate logarithms.

For example, what is the logarithm of 4?

The dotted line shows how it is found. It is just a "hair" more than 0.6.

Anybody familiar with logarithms will now understand the rest.

It is more convenient, of course, to make the drawing on squared paper, but if such paper is not handy one can easily do without and use plain paper.

Of course, this is not claimed to be "better" than a logarithm table, nor is it as good, but as an approximate method results will be found to be "pretty close" to the tabular results. Best of all is its simplicity and the ease with which this method can be remembered.

Marking Brown Prints.—Brown prints can be marked by means of a mixture of hydrochloric acid and peroxide of hydrogen. Another method is to use a weak solution of corrosive sublimate. This can be made by dissolving a small tablet of bichloride of mercury in water and using as ink with pen or brush.

PETROLEUM ENGINEERING.

The first oil well in this country was drilled less than 60 years ago, but since that time the petroleum industry has had a phenomenal growth. Technical advances in the business were slow at first but of recent years they have become of sufficient importance to merit the serious attention of engineers. In fact not a few engineers are now specializing in petroleum engineering. Some of the opportunities in this line are described by Prof. S. L. Galpin, of Iowa State College, in the November Iowa Engineer, from which the following notes are taken:

The leaping consumption of certain petroleum distillates added to a waning affluence in several important fields has created an urgent need for men capable of reducing production costs and eliminating waste. Hence the petroleum engineer, a composite of inventor, mechanician, surveyor, geologist and businessman, whose position in oil companies is rapidly becoming one of marked importance.

The continued existence of a producing oil company is entirely dependent upon the acquisition of new ground as the life of a developed "pool" is seldom more than a few years. It has been common practice to lease lands covering thousands of acres in the hope that oil may be found somewhere within the controlled territory. In the days of free leases this was not expensive, but now, with rentals of perhaps $1 per acre per year and an initial bonus, often greater than the actual value of the land, it is an extravagant procedure and unnecessary, since in most cases it is possible for one with sufficient geological training to locate the areas where oil concentration is most probable.

Arch or dome-like structures in oil bearing strata offer most favorable conditions for petroleum accumulation. The geologist locates these structures through an examination and correlation of rocks showing at the surface. Many companies have adopted this method of selecting their leases, thereby saving useless rentals and the cost of drilling wells in unfavorable territory. In some cases geological departments are maintained with a corps of as high as 30 members. The petroleum engineer may not be actively engaged in the work of prospecting, but it is to his advantage to understand the principles upon which the geologist makes his recommendations.

The drilling of test—or "wild cat"—wells is the second step in changing virgin territory to a producing "pool." In this work the engineer becomes an important factor. Few persons, other than those of the profession, realize the difficulties encountered while drilling and completing an oil well. The drilling cable may break, dropping the "tools" to the bottom of the hole; the casing often "freezes" or sticks in the bore because of side pressure from "caving" formations. Efforts to dislodge the "string" may break the pipe and allow the lower portion to clog the hole. Water must be completely shut out from the inner casing before the oil bearing stratum is entered. In addition to the usual hazards, the drilling of test wells is particularly difficult because of uncertainty in regard to the exact rock formations to be penetrated, and further for the reason that repair parts, fuel and water may not be readily obtained. To avoid or overcome these and other obstacles requires no little engineering ingenuity.

If oil or gas is found in paying quantities at the test well, the problems of control, transportation, and further development present themselves. Some "pools" have become notorious through the waste incident to the completion of wells which have "come in" under heavy pressure, but scientific methods are now in use which prevent such disasters except in extreme cases. The losses of gas and oil during transportation and storage are excessive and are due mainly to evaporation or "weathering"; to fire from lightning or other causes; and to leakage. Preparedness both in mental and material equipment is the keynote of success in preventing and combating these causes of loss.

Scientific development of an oil property is based upon the nature and extent of the oil bearing rock; the pressure curves for the different wells; the variety of oil produced; the proximity of invading water; competition; and upon market conditions. The first three factors are mainly geologic and are used to decide upon the proper spacing of the wells. Water, in its proper place, is indispensable, but if allowed to encroach too rapidly it becomes one of the most dangerous enemies of the producing well, and once admitted it soon displaces the oil. The flooding of "pools" from some abandoned, but carelessly plugged hole, is still of too frequent occurrence. Competition with other companies operating adjoining leases is often a serious hindrance to the best development of a property. Oil and gas belong legally to the parties which bring them to the surface, and it is quite possible to drain a considerable portion of one lease from another. To prevent this, the operator must "off-set" any damaging wells before channels become thoroughly opened toward the competitor's pumps. This practice protects the individual company, but at an expense which may be avoided if a proper agreement is reached in regard to the location of wells on adjoining leases. The engineers for two competing companies may be largely instrumental in procuring the desired truce.

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As a property is "developed" there is yet work for the technical man in planning and installing central pumping stations, gas traps, casing head gasoline plants, and methods for keeping up the flow from the pumps as the natural well pressures decline. Air or water may be forced down one well to increase the pressure in others, while vacuum outfits and agitators are successful in some cases. The proper system, skillfully operated, may increase the net return from a single lease many thousands of dollars.

Values on oil properties are fixed for taxation by appraisal at regular intervals. Because of the numerous variable factors which influence these values, the work should be done only by one acquainted with every phase of the oil business. Few are truly qualified, but the diversity and detail of the petroleum engineer's occupations afford an excellent preparation for this duty which he is frequently called upon to perform.

There is now a "brisk" demand for technical and scientific workers in the oil fields of this country. That the future needs for specialists in this industry must increase, partly as a natural development and partly because of the ever rising cost of production, seems certain. The exhaustion of old territories and the development of new, can but multiply the problems and difficulties of meeting consumption requirements. If such indications and suppositions are correct, the time is not far off when the petroleum engineer will be necessary, rather than an optional officer in every company successfully producing either natural gas or oil.

METHOD AND COST OF PLANE TABLE SURVEYS FOR AN IRRIGATION PROJECT.

The cost of plane tabling for an irrigation project in Alberta, Canada, was approximately 10 ct. per acre. The work was carried out in 1915 on the Lethbridge Northern irrigation project by engineers of the Irrigation Branch of the Department of the Interior of Canada.

A party of three plane-tables was organized in Lethbridge and consisted of the following men: Field engineer in charge of party, three assistant engineers, one draughtsman, six rodman, three teamsters and one cook, with a camp and transport equipment of 8 tents, 2 wagons, 3 democrats and 10 horses.

This party commenced field work on April 29, and finished for the season on Nov. 22, 1915, a period of 179 working days, covering 119,015 acres of topography, which is an average rate of 221 acres per plane-table day. No account was taken of a total of 25 working days which were lost during the season on account of bad weather.

A second party of three plane-tables was put on this work in September. This party commenced plane-tabling on Sept. 17 and finished for the season on Nov. 19, a period of 55 working days, covering 30,500 acres of topography at an average rate of 185 acres per plane-table day.

A total area of 149,515 acres was contoured during the season and in addition 315 miles of levels were run, setting bench-marks for the plane-table work.

The total cost of surveys for the season of 1915 was as follows:

Wages of party for the field season	$ 8,852.31
Commissary (subsistence, fuel and cook's wages)	2,918.56
Horses (hay, oats and supplies)	619.00
Miscellaneous	625.03
Draftsman (4 months extra to finish plans)	300.00
Total cost	$13,314.90
Total area plane-tabled, acres	149,515
Cost per acre, ct	8.9

Allowing a depreciation on outfit of $1,500 for the season, the cost per acre plane-tabled would be approximately 10 ct.

Each plane-table party consisted of an assistant engineer, two rodmen and teamster, the teamster acting as recorder to the instrument man. The scale of the plans was 400 ft. to 1 in., allowing one section to be shown on each plan. Beginning with a measured base line at least 1,200 ft. long, a closed plane-table survey was made of each section. The limit of error of closure allowed was 1/20 in. in plan, which at the scale used equals 20 ft. The limit of error for plane-table levels on each section was 2/10. All plane-table stations were set by triangulation from the base line, as were also all mounds.

The greater part of the work was done by taking spot levels, over the whole area, at distances apart varying from 100 to 400 ft., depending on the roughness of the land. The contours were then sketched on the plans in the field by interpolation. In giving the spot levels, care was taken to outline all sinks, knolls, drainage lines and saddle. All buildings, houses and fences were noted, also the character of the soil and the name of the owner of each parcel of land.

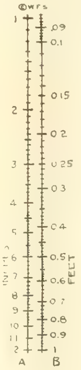
A reference bench-mark was placed on all wells and a note made of the elevation of the water level where it was possible to get it.

It was found that the work could be expedited considerably by setting up a level beside the plane-table at each station for reading elevations, using the plane-table alidade for stadia distance and direction only. This saved the time of the continual adjustment of the alidade telescope, necessary to keep it in a level position.

A HANDY INCHES-FEET CONVERSION SCALE.

Contributed by W. F. Schaphorst.*

We often see tables of decimal equivalents, of sixteenths, thirty-seconds, sixty-fourths of an inch, etc., converted into hundredths and thousandths. But I have never seen a conversion scale for changing inches over into feet or decimals of a foot.



I have therefore constructed this handy little scale.

Simply glance across from column A to column B and the value of any number of inches from 1 to 12 is immediately found. This scale has the further advantage of immediately converting fractional parts of an inch into feet at the same time.

For example, 4½ in. is what part of a foot? Answer: 0.375 ft.

The scale may also be used the other way just as easily.

For example, 0.1 ft. equals how many inches? The answer is, 1.2 in. Simply glance from the 0.1 (column B) to column A.

In case the number of inches is greater or less than anything shown on this chart the correct result is easily found anyway by simply keeping track of the decimal point. For example—

40 in. = 3.33 ft.
0.4 in. = .0333 ft.

The Municipal bridge of St. Louis, Mo., was formally opened to traffic on January 20. The structure is stated to have cost over $6,000,000.

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ILLOGICAL METHODS OF RATING HUMAN QUALITIES IN SELECTING MEN, OR ACCOUNTING FOR RELATIVE SUCCESS.

By Halbert P. Gillette.

Name in order of importance the following six organs: Heart, lungs, intestines, liver, kidneys, pancreas.

To put such a question would itself raise a question—a question as to the questioner's seriousness or his sanity. Yet if 10,000 men are asked to name the order of importance of certain mental faculties or qualities, there are few who will refrain from expressing an opinion offhand. Thus, when the members of the national engineering societies were asked to rate the relative importance of six mental "qualities," almost 7,000 gave replies. It is my purpose briefly to question the rationality of answers to such questions. First, let us have the question that was put to these engineers by the Joint Committee on Engineering Education. It was:

> Please prefix numbers to the groups of qualities listed below to show the order of importance that you give them in judging the reasons for engineering success or in sizing up young men for employment or promotion:
>
> ...... Character, integrity, responsibility, resourcefulness, initiative.
> ...... Judgment, common sense, scientific attitude, perspective.
> ...... Efficiency, thoroughness, accuracy, industry.
> ...... Understanding of men, executive ability.
> ...... Knowledge of the fundamentals of engineering science.
> ...... Technique of practice and business.

In the November Bulletin of the Society for the Promotion of Engineering Education, C. R. Mann, of the Carnegie Foundation for the Advancement of Teaching, gives his deductions from the 5,441 answers to this question that were in regular form. He deduces the following rating:

	Per cent.
Character	24.0
Judgment	19.5
Efficiency	16.5
Understanding of men	15.0
Knowledge of fundamentals	15.0
Technique	10.0
Total	100.0

Mr. Mann says:

> The fact that character is rated at 24 per cent does not mean that an engineer can succeed with a 24 per cent character. It does mean that even a perfect character is but 24 per cent of the engineer's total equipment.

Does it? Where is it intimated in the original question that the qualities enumerated are all the qualities that should be embraced in an engineer's mental equipment? What of such qualities as imaginative power, strength of memory and courage? Are these of no consequence? And what of the scores of other qualities not embraced in the six headings given in the question? The omissions of many qualities should alone cause hesitation about answering the question put to the members of the engineering societies, but failure to define the qualities is an even greater reason for hesitancy.

Mental qualities are not easily defined in a philosophic way. Turn, for example, to Logic in the Encyclopedia Brittanica and read the 10 definitions of judgment there given, together with the statement that all 10 are in error.

Note, furthermore, what a mixture of different qualities are embraced under the heading of "Character" in the question under discussion. Wherein is "integrity" related to "initiative"?

Note also that some of the qualities named under one of the six headings are but species of the same qualities given under another heading. Does not "executive ability," for example, consist in the exercise of "judgment"? As a matter of fact is not "judgment" a term that here signifies ability to reason correctly? If not, what is it? If so, wherein can "judgment" be segregated from the other mental qualities that involve the ability to infer or reason?

The mind is a complex whose various actions are classifiable, but this does not mean that the brain itself is susceptible of an analysis into parts or regions corresponding to all the classes of its actions. We may focus our attention on one class of mental action, but this is not tantamount to saying that such a class of action can exist apart from other classes of action.

If those who propounded the question under discussion had defined each of the mental qualities, it is likely that they never would have sent it out to engineers for answer; for it is really unanswerable, as a whole, and only in part answerable by the assumption of conditions not stated in the question itself.

There is a fundamental principle of logic which, though not stated explicitly in books on logic, should be self-evident to any engineer or scientist.

When several causes interact in producing an effect, none of the causes can be assigned superior importance over any of the rest.

The question asked at the beginning of this article serves to illustrate this principle. Since human life is dependent on the six organs there named it is impossible to rate any one of the six organs as higher in importance than any of the rest. Similarly, since the professional success of an engineer is dependent on many mental qualities—inherited as well as developed by training—it is impracticable to assign any general order of importance to them. It is true, however, that for the performance of a definite function one or more of the mental qualities, if particularly pronounced, may lead its possessor to dominance. But the function to be performed must be named definitely before a question as to relative importance can be answered. Thus, if the function be that of original research in any engineering laboratory, two qualities, inventiveness and persistent thoroughness, are paramount. On the other hand, if the function be that of selecting and organizing a force of men, the quality called "executive ability" is paramount. Yet in answering the question under discussion only 2 per cent of the engineers drew any distinction between "judging the reasons for engineering success"—which is often largely a matter of executive ability or skill in self-advertising—and "sizing up men for employment," which is usually a radically different matter.

Let us now approach the question under consideration from a different avenue. Let us apply another principle of logic:

No two things can be quantitatively compared or rated except in terms of a common unit of measure applicable to both.

Applying this generalization to the question under discussion, what is the common unit of measure applicable, say, to "integrity" and to "technique of practice"? What unit of measure is common to "resourcefulness" and to "accuracy"?

No one would be likely to attempt to compare quantitatively a rose with a star, except in two respects—mass and dimensions—for these are the only two kinds of units known to be applicable to both. Yet few engineers could resist the invitation to name "the order of importance" of mental qualities that have no common measure, save perhaps that connoted in the vague word "success." If we interpret "success" to mean profit, there are several sorts of profit—profit to the individual, profit to his employer, profit to the society in which he lives, profit to society in general. In brief we must define our unit or standard of measure before we can "rate" any two things, and we must be sure that the same unit is applicable to both.

Suppose a body of engineers were asked this question: Can you name the order of importance of a pine tree and a prune? If the question were taken seriously, what engineer would fail to ask: Importance in what respect? In relative size? In amount of carbon available for fuel? In quantity of nutritive matter? To a hungry man a prune is more important than a forest of pines. To a freezing man, a limb from a pine is more important than a carload of prunes.

It would seem that most of the engineers to whom the question under discussion was submitted would either have demanded, or themselves have stated, the common unit of measure. That they did not do so is apparently good evidence that few of them had studied logic. Isn't there much significance in the fact that not a single book on logic is to be found in the libraries of the four national engineering societies? Logic is presumed to be the science of reasoning—the science of sciences—and engineering is the application of science, not one science but all science. Something is wrong either with logic as it is taught, or with engineering as it is ordinarily taught, or with both. I am inclined to think that neither logic nor engineering are commonly taught well.

Words that have meaning are merely symbols of energy or the three quantitative categories of energy—mass, distance, time. Words are tools that facilitate reasoning, provided their true significance in terms of energy is understood; but when the energy significance is not understood, words are a positive hindrance to reasoning, leading frequently to the most absurd conclusions. As exemplifying the truth of the latter part of the last sentence, consider the absurdity of the conclusion reached by Mr. Mann, namely, that "even a perfect character is but 24 per cent of the engineer's total equipment." Starting with words that were not defined, formulating a question that does not accord with two fundamental principles of logic, collecting answers from 7,000 engineers, applying mathematics to the answers, we get what? Pure nonsense, yet a sort of nonsense that parades as science.

I will not now discuss another underlying fallacy in this whole procedure, namely, the belief that wisdom lies in the beliefs of the multitude. There are some topics on which expressions of opinion by many experts are illuminating. There are other topics on which expressions of opinion of the same experts are worthless, because they have given the matter inadequate study.

HYDROGRAPHIC SURVEYS: RECENT IMPROVEMENTS IN APPARATUS AND METHODS.*

Observation by means of the sextant from vessels or boats remains the only feasible method of location where large areas are involved, but more and more attention is being paid to the determination by triangulation rather than by weaker methods of all or at least all the important shore objects used.

There is a region of great extent, particularly along our Atlantic Coast between the outer line where positions can be obtained directly or indirectly from the shore and the 100-fathom curve. The inner limit averages about 15 miles of shore while the outer may be as much as 100 miles, with a general average of 75 for much of the Atlantic Coast. In the past the results of surveys in this region have been far from satisfactory, as the proper treatment of the effect of current on the moving vessel has not been made. Two years ago the practice of stopping the vessel every two hours and anchoring for current observations was adopted. The results of this simple change are startling. When this entire region has been surveyed the charts will be infinitely more valuable for their chief use: the affording to the navigator of a means of determining or checking his position when approaching land in foggy or hazy weather. The importance of meteorological currents in this connection is at times very marked, as such currents may temporarily supplant the normal flow.

Depth measurement is the constant subject of study with a view to obtaining more accurate results. For example, the pressure tubes on the market are not entirely satisfactory and it will be necessary to improve these The hand lead which has been the chief reliance in critical depths is not entirely satisfactory. The method, though it best meets a wide variety of conditions has many defects. As yet no shape of sinker has been devised which will sink more readily than the standard form of lead on the market and yet which will not penetrate the soft bottom. The currents and motion of the vessel produces lateral forces on the lead line which cause error. In smooth water the reading can be taken with accuracy, but when there is a sea or swell, the more common condition in hydrographic work, it is far more difficult. Even a trained leadsman will have a personal equation in estimating the mean height of the wave. His position directly above the point of reading is not the best for accurate judgment, and, besides, the mean height of the wave is not the same as the smooth water level on account of the shape of the wave. For a wave 60 ft. long and 4 ft. in height, the difference is about 2 in. This is a minor correction, but one of which many hydrographers have probably never realized the existence.

It became evident not many years ago that in all localities where rock formations occur in areas of moderate depth, vertical measurements are not sufficient even if made in immense numbers at a prohibitive cost. The area of some projections is much smaller than the smallest space which can be left between soundings. These small projections, while of small importance when occurring on land, may be serious dangers if submerged and unknown. The problem of locating projecting rocks has been to a large measure solved by the adoption and development of the wire drag method.

This method may be defined mathematically as the development by means of a line of a series of planes, either horizontal or slightly inclined at a known distance below a datum plane. The purpose is to intercept all projections above the planes generated, whereupon the method of vertical measurements is used to determine the contours and height of projection and its horizontal position is also fixed.

Two aims not contradictory, but one more far reaching than the other are capable of adoption: to meet the pressing needs of navigation and to attain scientific accuracy. A review of results thus far obtained by this method indicates that much more has been done than to meet the former requirement, but that the latter has not been fully attained, though the accuracy has steadily increased.

Wire Drag, Type of 1916, as Perfected by the U. S. Coast and Geodetic Survey.

There are two classes of wire drag work. These may be called maximum depth or deep water drag work and close to bottom or moderate depth drag work.

It has been found that in certain localities there is a possibility of the existence of projection of considerable height above the bottom, and it is necessary to apply the wire drag method even though the known depths may be considerably greater than the draft of the largest vessels. The depth of the plane to be generated below the datum plane is fixed by considering such vessels under the conditions when the point of maximum draft has reached its lowest possible position below the datum plane. Starting with the draft when at rest corrections are applied for effect of speed and of waves, for abnormally low tides and for possible drag error. The resulting value is fixed as standard for an entire region of like navigational requirements. For much of the Atlantic Coast this is now fixed at 50 ft., though 5 years ago 36 ft. was considered ample. The possible needs of submarines and their vulnerability is making it necessary to increase the former figure for some localities, 70 ft. having been used in one instance. This class of work is comparatively simple and its value is chiefly negative as its purpose is the disproving of the existence of projections, though it must be certain that no projections are missed. As large areas can be rapidly covered with the use of a drag 2½ miles in length the unit cost of such work is low enough to make it a necessary precaution.

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*From a paper by N. H. Heck, Assistant, U. S. Coast and Geodetic Survey, presented Dec. 29 before Section D of the American Association for the Advancement of Science.

The more difficult class of work is that of locating obstructions when the wire must pass close to the known bottom. It must be possible to cover a reasonably wide area at each sweep, and to constantly alter the verticals so that the horizontal wire takes the correct position. The requirement on which all else depends is the certainty with which the wire remains in contact with the rock. The selective action with which the wire strikes and remains in contact with any projection, no matter how slight, above its plane, and yet passes over all below it, is the sure measure of the value of the method. It is also necessary that from the period of striking until the removal of the wire the part near the rock shall remain in contact, while it is necessary that the weight of the remainder of the wire shall be balanced and slightly exceeded by the buoying power of floats attached at suitable intervals.

It was the absolute need for an apparatus which would meet all these requirements which led to a continuous process of experiment and rejection from the time of the adoption of the idea from the U. S. Lake Survey in 1906 to the present development of an apparatus, differing in many respects from its prototype, which meets present requirements to a satisfactory degree. A solution of the many problems at one time appeared hopeless, but it was a matter of necessity. The area where the need of this method is imperative includes part of the approaches to all the important Atlantic Coast ports from New York to the Canadian border, and practically all of the inshore area and bays along this portion of the coast; also the coral areas of the Florda Reefs and Pórto Rico. The problem on the western coast and Alaska is intermediate between the two methods described, as there the projections usually rise to a considrable height from deep water.

The use of an upward force to overbalance the weight of the wire which cannot be entirely elminated by the tension introduces a condition of instability which is undesirable, but which cannot be avoided. Careful adjustment of the buoyant force applied is necessary—too much buoyancy will destroy the value of the drag while too little will cause the wire to catch throughout its length and stop progress.

For a long time experience was the only guide, and empirical methods appeared sufficient. There appeared to be no practical way in which the operations could be studied, especially those which are invisible. There was also a partly psychological reason. A new method when applied to a region believed to be comparatively free from obstruction proved the existence of a surprisingly large number. So great a contrast made it appear that a method which could produce such surprising results was certain to be final. The precaution of measuring the actual depth at which the wire passed below the surface and of applying an additional correction to the depth thus obtained was taken. The weakness of this method is that it gives no index of the catching power of the wire.

The analysis of this problem is complicated. The instant before striking the drag is moving freely, its motion being governed by a large number of forces which may be determined in amount and direction by the principles of hydro-mechanics. The actual curve can be deduced and many observed phenomena can be explained. There is an opportunity to make useful observations in regard to low velocity resistance as all published experiments refer to higher velocities than 1½ miles per hour. It is hoped that in the future this may be done.

The observed phenomena, which occur when the wire catches on a rock, must be understood in order to appreciate the conditions. At the instant of contact the wire tends to change its position from a curve resembling a parabola to two straight lines leading directly toward the towing launches. The tension in the wire suddenly increases in proportion to the momentum and distance off of the launches. If the wire does not at once catch firmly it may slide up the surface of the rock, which will be evident by a sudden jump of the towing scales at the launch, or if one launch is causing a greater tension than the other for any reason longitudinal motion may occur, the wire acting on the rock as a belt on a pulley. It is important to know whether such motion increases the tendency to slip over. It is of the greatest importance if the wire does slip over that it should hold long enough for the fact to become evident.

At this point there enters a phase of geology, usually of little interest to the geologist. This is the exact shape of the surface of rocks and boulders. The smallest knob may cause the wire to hold. Where the rock surfaces have been polished by the ice in past ages it is necessary to place somewhat less confidence in the results of wire drag work.

This subject has been cleared up somewhat in the last few months by the observation and photographing of adjacent shore forms, and by actual experiments of the action of wire on rock. While not entirely conclusive they have definite value. A section of wire 50 ft. long of the same kind as used in drag work was stretched between two trucks running on tracks 12 ft. long whose height could be adjusted through several feet. Between the wire and one of the trucks there was inserted a spring balance and a turnbuckle, which afforded a means of securing the desired tension. Midway between the trucks a rock, of such weight that it could be shifted in position and yet heavy enough to prevent its being moved by the impact of the moving wire, was set up. The rock was set in a certain position and its inclination and character of surface where the wire would strike was noted. The trucks at the end were then moved simultaneously at a speed approximating that of the average drag, about 1½ miles per hour. The action of the wire on striking was observed and noted. When the wire slipped over it was noted whether the action was a spring or a rolling of the wire. A modification was the substitution of an endless wire by means of blocks. In this way simultaneous longitudinal movement of the wire was obtained.

Only the general conclusions can be given. Whenever the angle of inclination exceeded 30° to the horizontal there was no uncertainty no matter how smooth the surface. Between 20° and 30° there was a doubtful zone with the wire usually first catching and then slipping over. Under 20° the wire slipped freely. An increase in the amount of rock surface in contact with the wire reduced the angle of slipping.

The conditions of these experiments are of course not identical with the action of the drag, and would be of little use without other evidence. With the drag tension is applied at distant points, and all the elements of drag design enter into the problem. The size of the various sinkers, the interval between them, the buoyant force of the floats, and their spacing and inclination of the wires between them, all have a bearing on the action of the drag.

As a result of observation of the behavior of the wire drag for a long period and after examining the plotted results, comparing the soundings with the effective depth of the wire passing over them, a definite statement can be made.

In all areas of rocky bottom, where the rock is ragged and sharp, which is the more common condition except in glaciated regions, the action of the wire is sure and full reliance may be placed on the results, provided the proper corrections have been applied. In boulder regions there is a degree of uncertainty which can be eliminated by only one method. Such regions are usually of flat, generally muddy, bottom with boulders or boulder groups projecting at intervals. It is possible to eliminate doubt by passing the wire very close to the general bottom or actually make it slide over the mud. In this case practically all boulders will be struck below their greatest diameter and the wire will hold. This method is expensive as the slightest projection, even if of no importance, will stop the wire. The precaution is unnecessary so long as the navigator understands the condition and allows a greater margin of safety than elsewhere.

A recent type of small buoy which resembles in shape an electric light bulb and passes through the water very easily, meets every requirement. Three kinds of wire are now used, each best suited to its special purpose. There is an interesting contrast between the drag wire now used, which has a breaking strength of 4,000 lb. as against 500 lb. for the wire used in 1904.

The system of measurements has been standardized. All drag parts are measured in feet, and an invariable system of dividing all vertical members into sections 10 ft. in length has been extended to the lead lines. The use of the fathom has been eliminated. All measurements relating to the sheets are in meters, so that a decimal system is used throughout. Three instruments have been specially devised for wire drag plotting.

INSTRUCTIONS AND WORK ACCOMPLISHED BY CANADIAN STADIA SURVEY.

The first large stadia survey undertaken by the Irrigation Branch of the Department of Interior of Canada, was carried out in 1915. The survey was made on the channel of Milk River to determine the exact conditions existing at that time. The party, consisting of 12 men, took the field on July 3, 1915, and was disbanded on Nov. 29, completing a season of 103 days actually on the line. About the middle of September the party was increased to 14 men. The more important instructions issued by the Commissioner of Irrigation for the work were as follows:

Traverse of River Banks.

The traverse of the river shall be made in accordance with the regulations laid down in the Manual of Instructions for the survey of Dominion lands, and both banks of the river shall be accurately located.

The traverse shall be a stadia traverse; that is to say, both the courses and offsets shall be measured by stadia method.

The length of any course shall not exceed 600 ft., and offsets shall not exceed 500 ft. in length. Offsets shall be observed to locate all determining points of change along both river banks, and shall be at an interval not greater than 100 ft. along each bank. All distances shall be recorded in feet and tenths of a foot.

The vertical angle in measuring any traverse course shall not exceed 5° and horizontal distance shall be corrected for any vertical angle of 2° or greater.

For measuring offsets the vertical angle shall not exceed 15° and the horizontal distance shall be corrected for all vertical angles of 5° or over.

The traverse shall be accurately tied to Dominion land survey monuments at least every 3 miles.

The stadia offset shots shall show the elevation as well as the location of the top of bank.

The stadia traverse levels shall be corrected to agree with the regular level line, but separate levels shall be run by the stadia transit as a rough check on the level line.

All permanent iron bench marks set shall be accurately tied to the traverse survey line.

Both banks of the main or any secondary channel, as well as all islands, shall be accurately located.

The junction of all tributary watercourses shall be located and shown in the notes.

Levels.

The datum of the level line shall be reduced to mean sea level datum.

The datum of elevation shall be gained from bench mark No. 575, located in NE. ¼ Section 11, Township 1, Range 23, W. 4th meridian, and the levels shall be checked by connecting with the permanent iron bench marks which have been set by the irrigation surveys at Milk River station and at the south end of Pakowki Lake.

A permanent iron bench mark shall be set at or near the crossing of every township line, and elevations shall be determined for all permanent iron bench marks set by the Hydrographic Surveys Branch along the channel of the Milk River.

The limit of error in the level line should not exceed .05 distance in miles and if the error exceeds 0.1 distance in miles the levels must be rerun and the error checked. The errors shall be determined by checking with the permanent iron bench marks mentioned above.

The elevation shall be determined for every traverse hub.

An accurate cross-section of the river taken from bank to bank and extending at least 50 ft. on each side shall be made every 2 miles of river meander, and every cross-section must be accurately located from the traverse line. In determining the cross-sections elevation shall be gained at horizontal distance of not over 5 ft.

Below Pakowki Lake the levels must be checked by rerunning each day's work, or else by running one check line from the eastern crossing to the last permanent iron bench mark which was checked at Pakowki Lake.

A search shall be made for all bench marks located by L. E. Fontaine, D. L. S., and wherever they are found their elevation must be noted.

Notes and Sketches for Land Classification.

The object of this part of the survey is to obtain by notes and sketches the agricultural value of any lands which may possibly be damaged or destroyed by erosion or overflowing on both sides of the river.

Complete notes and sketches shall be made of all lands bordering on the river or other lands which by virtue of their elevation are liable to be eroded, destroyed or damaged by an extreme stage of flow in the river, or by it changing its course.

All changes of the classification of lands must be noted and sketched in wherever necessary.

The classification of the soil shall be as laid down in the Dominion Land Survey Manual and in addition to this all trees or other vegetable covering must be carefully noted, with an estimation of of any commercial value they may have.

All notes and sketches shall be referred to the traverse line.

It is desirable that the notes should indicate the surface slope and distance from the river banks to the edge of the main valley hills at sufficiently frequent intervals to indicate the average width of the river valley through every section of land.

The accuracy and closeness of the details shall be in accordance with the liability of the land to damage.

Plan.

The plan shall be plotted to a scale of 400 ft. to the inch on a continuous roll of paper. Two sets of field books shall be used, being taken out in the field on alternate days, and the plan shall have all information gained plotted up not later than one day after the information has been gained in the field. At the end of each week, after having been O. K.'d by the officer in charge, shall be inked in.

Each cross-section of the river taken in the field shall be located on the plan and numbered with reference to the chainage on the traverse line.

All sections shall be plotted on a continuous roll of cross-section paper, numbered the same as on the plan, and plotted to a scale of 50 ft. to the inch horizontal, and 5 ft. to the inch vertical.

Standard irrigation office conventional signs shall be used, unless these conflict with any instructions in the Dominion Land Survey Manual, when the latter shall rule.

The scale of 400 ft. to 1 in. was found to be too small to show the information in sufficient detail, and was changed to 200 ft. to 1 in.

It was found to be impossible for one draughtsman to keep the work plotted to date, as required under the instructions, and this was unfortunate, because the work was to some extent retarded on this account.

Owing to the difficulty, and sometimes impossibility of getting down to the Milk River, whenever necessary, with teams, it was decided that the best means of transporting the party along the river would be by canoes, and accordingly three large freight canoes were furnished, to which were added later in the season a small cedar skiff.

Considerable difficulty was found in moving camp with canoes along the north fork of the river. The river was altogether too shallow to float canoes under the loads found necessary to carry. In addition to the usual camp equipment, on account of the very wet and cold weather, it was necessary to carry heating stoves and coal, so that the canoes did not prove satisfactory on the upper stretches of the river.

As Milk River station was approached, a large portion of the equipment, not immediately required, was shipped into the storehouse there, and the move from middle of Range 20 to the town of Milk River was made in one trip of the canoes.

Another objection to the use of canoes only was that no means were provided for getting provisions to the camp, and until a team and wagon was furnished the party had to depend altogether on outside sources which sometimes were not reliable, and consequently the party was often short of provisions.

During the month of July, the progress of the work was not satisfactory, owing to a misunderstanding of the instructions. During this time all of the topography was located by instrument, whereas it was considered only necessary to sketch the most of this, estimating distances and elevations mostly by eye. Although the method of using an instrument to locate the topography was of course very accurate it made the progress very slow.

After the proper procedure had been explained, the progress of the work was better, but it was soon evident that in order to complete the survey during the field season of 1915, still greater progress would have to be made by the party. Instructions were therefore issued to reorganize the party if necessary and increase it to such an extent that the work would be completed during the season.

By the addition of one rodman it was found possible to use two instruments on line, which greatly increased the speed of the work, and although along the lower part of the river valley the country became much rougher, the hours of daylight less, and progress otherwise retarded by the heavy growth of bush along the river, the survey was completed during the season.

Table I shows the work done at each camp.

There were 1,706 courses in the main traverse line, which was 181 miles long. The length of river meander traversed was over 217 miles, exclusive of subsidiary channels of all kinds. The length of the traverse line from the initial point on the international boundary line to the most easterly crossing of the international boundary by traverse line is 180 miles and the length of the river meander between the same point is 216 miles. Cross sections of the river channel were taken at 131 points. Ties were made to township surveys at 43 points, of which six were along the international boundary.

TABLE I—STADIA TRAVERSE OF MILK RIVER.

Camp No.	Calendar week days.	Net days on line.	Total miles traverse line.	Total miles river meander.	Length of traverse as per cent of river meander.	Miles traverse line per calendar week day.	Miles river per calendar week day.	Miles traverse per net day on line.	Miles river per net day on line.
1.	13	9*	3-28	5-93	55	0-26	0-46	0-36	0-65
2.	10	8-25	8-13	12-59	65	0-81	1-26	0-99	1-53
3.	6	4-75	7-40	11-38	65	1-23	1-90	1-56	2-40
4.	4	2-25	3-09	4-43	70	0-77	1-11	1-37	1-97
5.	9	7-5	9-42	15-59	60	1-05	1-73	1-26	2-08
6.	9	7-25	14-65	20-38	72	1-63	2-26	2-02	2-81
7.	7	5	10-91	11-63	94	1-56	1-66	2-18	2-33
8.	7	5	12-73	15-32	83	1-82	2-19	2-55	3-06
9.	9	8	22-04	25-74	86	2-45	2-86	2-75	3-22
10.	10	7-75	19-21	20-63	93	1-92	2-07	2-48	2-67
11.	8	7	17-00	17-27	98	2-12	2-16	2-43	2-47
12.	10	9	17-26	18-33	94	1-73	1-83	1-92	2-04
13.	17	13	22-16	23-14	96	1-30	1-36	1-70	1-78
14.	9	9†	13-79	14-66	94	1-53	1-63	1-53	1-63
Totals.	128	102-75	181-07	217-07	83	1-41	1-70	1-76	2-11

*July 5 not included. †Nov. 29 not included

Note: Except the two dates noted, net days on line include all time on line; no deductions for side lines, section lines, cutting brush, etc. The mileage columns do not include any side lines or tie lines.

Mounting Tracings on Muslin.—The following method for mounting tracing cloth drawings on muslin is given by John W. Grantland in Popular Mechanics: Stretch a piece of starched muslin, slightly larger than the drawing, on a flat, smooth board, fastening it with tacks. Coat the back of the tracing with a good varnish, and place it, face down, on a flat surface so that it may partly dry and become tacky, which usually takes two hours. Place the tracing upon the stretched muslin, varnished side down, and place a smooth sheet of wrapping paper over it. Using a moderately warm flatiron, and beginning at the center of the tracing, iron toward the edges, applying moderate pressure. To remove the tracing from the cloth, it is necessary to warm the cloth with the iron and strip the tracing and cloth apart gradually.

Method of Making Tide Observations.—In connection with its revision work this fall between Boston and Cape Ann, the following method was employed by the U. S. Coast and Geodetic Survey for making observations of tides in connection with current observations: A vertical wire was attached at the bottom to a flat, weighted board which could neither penetrate the bottom nor be readily lifted from it, and at the surface to a float with ample slack wire. At a suitable distance below the surface a graduated cotton line was attached to the wire so that its zero would be a little below the surface. After each current observation the gauge was visited in a rowboat, enough tension was placed on the wire to straighten it, and the gauge was read.

LANDSCAPE ENGINEERING.*

Among the problems of the landscape architect that of grading or the handling of earth is probably of the first importance. This would be accomplished as the general engineer would do it with anything from a slip scraper to a drag-line dredge, depending on the job and the amount of earth to be handled. There would, however, be some differences. First, provision and thought must be given from the very beginning of the work for the stripping and saving of all topsoil or loam. This will be done even where it is necessary to store it in piles and handle it twice. This saving of loam is of the utmost importance in all grading where any attempt is to be made at the growing of vegetation on the surface of the finished work and is the first great care of landscape architects. As the average price of topsoil is $2 per yard, it is readily seen that considerable rehandling may be done and actual money saved by this preliminary stripping of black earth. Second, the masses of earth must be excavated or deposited in such a manner that they will fit into the geologic surface formation of the district as nearly as is possible. This is to get a natural appearance. That is, a lake or stream will be excavated so as to appear as though it had always existed and an embankment will be constructed so that it will seem to have been glaciated and smoothed off with weathering and rainfall. The specifying of a 1½ to 1 or of a 2 to 1 slope, as is general in engineering, is hardly possible in landscape work.

A slope in general will lay in some form of a reverse curve and this is generally determined by direct supervision on the ground with at times the assistance of a proposed contour plan. On the surface of the subgrade a layer of loam will be placed, its depth depending on the vegetation to be supported and the amount available. At times ledge rock may be inserted in this if the geology of the district calls for it.

Around impressive buildings a natural setting would not in general be desirable and here formal or architectural forms, as distinct flat lawns and terraces, are used. This is good design around an imposing building, because here the building is and should be the dominating feature. Where, however, the building is residential rather than imposing in character, the use of distinct terraces is never very satisfying. It implies too great a cost in grading for the importance of the house.

As of course it is not always possible to fit certain definite requirements and maintain an absolutely natural feeling, the landscape architect must at times resort to the use of retaining walls and dams. Such walls may be anything from a dry wall to a reinforced concrete wall. In informal work the dry wall, or at least the rock-faced wall, will be preferred to the plain concrete-faced wall. By rock-faced is not meant the much used boulder-faced wall, which always has the effect of being on the point of collapse. Split and hammer dressed boulders may, however, often be used effectively. In formal design, of course, practically any type of wall may be used as long as it looks well with the house involved. The landscape architect's retaining wall will then only differ in design from that of the engineer in that he will be very much interested in getting a fitting appearance as well as being sure that the wall will stand up.

The problem for the design of a dam that usually comes into the landscape office is that of building one that will stimulate the waterfall rather than look like a dam. This is generally accomplished by building a concrete structure faced with ledge-rock. The placing of this rock is of the utmost importance and can generally only be done by personal supervision. This treatment will of course give a structure that would be bad from an engineering standpoint, as it will have a very uneven spillway and face for the water to flow over; however, as in general only a small stream is involved, and the appearance is a great factor, the risk is worth the effect. The greater the breaking up of the water the more the client will be pleased, and this of course is one object to be attained.

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*From [illegible] presented [illegible] before the [illegible] printed in the January Bulletin of the Affiliated Engineering Societies of Minnesota.

In order that any tract of land may be enjoyed it must be accessible, both to get to it, and to travel within it. This requires trails, paths and roads. Some of these will require a surface metal and hence the landscape man in charge of the development of a piece of land must know roads and pavements, and the proper kind to use in the proper place. The placing of any particular wearing surface would not of course differ from that used by the general engineer.

Roads require bridges and hence the small bridge is a frequent problem. In a wild, rugged setting a rock-faced concrete arched bridge will generally give the best appearance; however, in a much used city park a light, plain concrete bridge is very appropriate.

Roads as well as other areas require drainage and hence the landscape man must be able to take care of the storm water on the land that he is treating. As the drainage is mostly underground, ordinary engineering principles apply and there is little chance for artistic work.

The residential subdivision is frequently put in the hands of a landscape architect. This will generally involve some sort of a curvilinear street system, not because the landscape architect believes that this is the most advisable type for any and all residential subdivisions, but because the owner will seldom go to the expense of retaining a man of this type unless the problem is of some difficulty. Rolling, hilly land requires a curved or irregular type of street line, and a flat plane, the straight gridiron form of streets and blocks. For a business or factory section of town the gridiron system of blocks and ways is without any doubt the most usable and the most desirable type. It is equally true that for the high class residential subdivision on rolling land, the curvilinear or irregular subdivision is the most pleasing and the most economical as well as the best selling type. At times on practically flat land a curved street may be desirable as a matter of adding interest in a town where each street is just like any other street.

The landscape architect is peculiarly adapted to the solving of the residential subdivision on a difficult piece of land, not because he knows more about the building of roads and of permissible road grades without excessive cuts than any other engineer, but because he does know how to arrange and utilize the lot unit to the best advantage. As his general business consists to a large degree in the study and arrangement of private places, it would naturally follow that he would develop a good knowledge as to what will constitute a good building lot and how it may best be made available for residential use.

The problem, then, for the proper solution of the residential subdivision resolves itself into finding where the best roads will go, first, to give the most usable lots, and, second, the most convenient blocks with the best looking streets on the easiest gradient.

In a particular problem of this character, the first requirement is a good topographic survey; this is very generally made by the landscape architect's office, not because a landscape architect can make a better survey than any other engineer, but because, being familiar with what he requires he is much more apt to take data on these points than any other surveyor. The second requirement is an accurate boundary survey, with very much emphasis on the word accurate. This survey will very often be made by a local surveyor who is generally able to solve the immediate intricacies of the local property lines to much better advantage than the man who is new to the district. The topographic and the boundary survey must, of course, be tied together. The kind and the accuracy of the topographic survey will depend on the problem involved. With 60, 70, and 80-ft. lots about a 50-ft. cross-section or its equivalent by stadia is necessary; where lots will range around an acre in size, the equivalent of a 100-ft. cross-section will be about right.

From this data sketch is generally drawn up to be submitted to the client which will show the preliminary arrangement of the plat. The basis of the scheme is as close and adherence to the topography of the area as is possible. In general the roads will follow the valleys and the lots will be above and drain towards the roads. This is the ideal condition and gives, as far as drainage and road grades are concerned, the most useful type of lot and road. However, the size and shape of a lot is also a considerable factor, and, as roads are primarily ways only to serve the lots, it is not always possible to simply follow the thread of a valley and have a necessarily good road. Roads will often have to be built on hillsides to serve certain areas involved. Further, the obtaining of a good line will often involve certain changes from the absolute center of a valley. The obtaining of an interesting view will also often affect the line of a street.

The study of the topography of the property involved in a subdivision cannot do otherwise than give an arrangement of blocks and ways that is bound to be far superior to simply taking a tee-square and triangle and lining up a system of blocks on a rectangular motive. One involves considerable thought and planning, while the other requires little or none, and hence it naturally follows that the one to which the most study is given is the better plan. The preliminary cost of the curvilinear plan is greater, but this is a small item in comparison with the value of the property involved and can be depended upon to enhance the value of a residential subdivision and cheapen the development of its lots and roads.

In the average subdivision little thought is given to the size of lots except to decide that 40 or 50-ft. lots will probably sell good. When be begin to consider topography it is immediately evident that certain areas of land form in themselves ideal lot units and should be kept as one lot, thus an inequality in the size and shapes of lots is bound to occur. For example, a good house site is generally to be found on a knoll and not in the valley between two knolls. But this valley is an excellent place for the property line between two lots. It is impossible to mention all the factors in the determination of a good lot because each lot is an individual problem in itself. The kind and size of lot that can probably be sold is of course a factor in the determination of the lot.

After the preliminary study of the problem has been accepted by the client, the purely engineering problem, of the determination of road profiles both for reasonable grades and for reasonable surface and underground drainage and the computing of the scheme of roadways and lot lines, is evolved. The subjects of road profiles and of drainage do not differ much from that required in any subdivision, with the exception that the profile must be studied with regard to the curve of the road as well as for gradient. The road as it lays on the ground is in four dimensions, and a profile, while good in itself, may ruin a curve which is excellent in plan, and vice versa.

In park work and on private estates roads and paths are generally determined on plan and these lines are roughly laid out on the ground by the most available method, as, from existing buildings, from topography or from a cross-section survey, perhaps. These rough lines are then restaked and smoothed out by the eye. The park curve is the curve found in nature, namely, some form of spiral. The curves of practically all growing things are in spiral form and this is probably the reason that the spiral appears the natural curve to best fit ground forms. Thus the curved park road should always be either increasing or decreasing in degree of curvature where a naturalistic effect is desired. Of course, if it is a formal piece of park work, that is another matter. Another empirical rule is that there shall always be a piece of tangent between two reversed curves, as this tends to give a strong virile line, and, on the other hand, that between two curves going in the same direction there never should be a piece of tangent, as this will give a weak line and a somewhat broken back effect to the curves involved. These three rules are the principal points to remember in the use of curves, not only for roads, but in general artistic design.

In the computation of a plat for a curved subdivision is required in this feature. Taking then the boundary survey that absolute accuracy, as near as it can be attained, is required in this feature. Taking then the bundary survey and knowing certain definite points that must be met and assuming others by scale from the plan, it is possible to compute every required point in a subdivision. An angle or distance once assumed by scale, of course, becomes definite and this requires that the plan be quite accurate from which any scaling is done. In computing the X and Y co-ordinates from an assumed quadrant such that all co-ordinates will be positive, are first determined for each P. I. and intersection. Having thus a skeleton framework throughout the plat the required regular curves are computed, using 50-ft. chord lengths instead of 100, as in all railroad work. Following this the lot lines are determined. There is no great difficulty in this, providing curved intersections are not involved, but unfortunately they generally are involved.

It is always best that two streets should intersect at a piece of tangent, even when this involves the placing of such a section between two curves going in the same direction. There are many economies in this, such as future computation of curb intersections, etc., as well as immediate ease in the determining of the intersection of the street center line. Further, it seems to be a wise provision of nature that unless there is a short piece of tangent visible before the curb line crosses the intersecting street, the eye does not seem able to carry the curved line across in perspective, and apparently there is a sharp break in the curve, the eye seemingly having a tendency to carry on the line of the curve on a tangent from the point of breaking off. Thus if we have a short piece of tangent on each side of an intersecting street, the eye will carry the line across on a tangent and no feeling of break will occur. At times, however, an intersection will take place on one side of the street only, and, if this is a curved street, a flat piece of tangent on the opposite side would be the more apparent of the two evils. Then it becomes necessary to have a curved intersection. This will involve the determination of the equation of the lines involved and the solution by analytic geometry for the points required. The determination of lot lines especially where they do not lie on radial lines to the street, will often also require the solution of equations. Fortunately, the radial lines are the most logical lot lines, as any line which gives an acute angle to the corner of a lot makes that portion of the lot hard to utilize.

Having thus computed the exact position of each point, it is possible to work up a deed plat that is accurate and from which, assuming that the original boundary survey is correct, any surveyor should be able to locate any lot with comparative ease. The method of laying out on the ground and measuring for the plat is bound to result in inaccuracies that are hard to find; however, with everything computed in advance, if the man in the field fails to check, he knows that something is wrong and proceeds to find it, either in his work or that of the office.

It is generally necessary in a residential section that provision be made for a building line. This line very much depends on the property involved and should seldom be less than 30 ft. from the street line, though it is not needful that it be uniform in all parts of the project. A certain amount of variation in the building line adds to the appearance of the street.

For actual usable width, 50 ft. is wide enough for any residence street carrying a purely local traffic originating on the street itself, providing an allowance is made for setting back the building line at least 30, making a practical width of 110 ft. between buildings. The Royal Commission on London traffic called for a width of from 40 to 60 ft. on fourth class or purely local streets and the standard for secondary German cities for local streets is 35 to 48 ft. Fifty feet will give a 24-ft. roadway, an 8-ft. boulevard and a 5-ft. walk, which is a good section for a local residence street. Where much through traffic is carried on the street, a wider paving will have to be provided of a width that will depend on the particulars of the case. Ordinarily an attempt is made to eliminate as far as is possible any through traffic on a residence street of the better class, and care only for that originating in the district itself.

To properly solve a subdivision, the sewer and water problem must always be kept in mind, though the actual layout of such a system would be up to a municipal engineer. The straight runs necessary between sewer manholes naturally do not lend themselves very well to curved streets and such an irregular street will often involve extra manholes. In a similar manner, where the curves are sharp, special fittings will become involved in the water system and gas mains.

I have outlined briefly the engineering problems that the landscape architect is required to solve, dwelling particularly on the subject of subdivisions. The architectural problems that he comes in contact with, if we omit the fact that as architecture is the Mother of Arts, any good design is perhaps architecture in its broad sense, are generally in conjunction with formal gardens and with small structures, as pergolas, shelter houses, pools, gateways, balustrades, vases, walls, bridges, etc.

A COST KEEPING SYSTEM FOR A SMALL MUNICIPAL DEPARTMENT.

Contributed by Robert J. H. Worcester

The town of Concord, Mass., maintains it's own force for building and maintaining its highways and bridges. The work is done by the Department of Roads and Bridges which is under the control of a Board of Road Commissioners, one of whom is elected each year for a 3-year term. The board has under it a highway engineer whom they appoint for a term of one year and who has the title of Superintendent of Roads and Bridges. The superintendent has charge of the design, construction and maintenance of roads, bridges and surface water drains, together with the purchase of materials and accounting for expenditures, all subject to the approval of the board.

TABLE I—HOURS AND MINUTES IN DECIMAL PARTS OF 8-HOUR DAY.

	Minutes											
Hours	0	5	10	15	20	25	30	35	40	45	50	55
0	0	0.010	0.021	0.031	0.042	0.052	0.063	0.073	0.083	0.094	0.104	0.115
1	0.125	0.135	0.146	0.156	0.167	0.177	0.188	0.198	0.208	0.219	0.229	0.239
2	0.256	0.260	0.271	0.281	0.292	0.302	0.312	0.323	0.334	0.344	0.354	0.364
3	0.375	0.386	0.396	0.407	0.417	0.427	0.438	0.448	0.458	0.469	0.479	0.490
4	0.500	0.510	0.521	0.531	0.542	0.552	0.562	0.573	0.583	0.594	0.604	0.614
5	0.625	0.635	0.646	0.656	0.667	0.677	0.688	0.698	0.708	0.719	0.729	0.739
6	0.750	0.761	0.771	0.782	0.792	0.802	0.813	0.823	0.833	0.844	0.854	0.864
7	0.875	0.885	0.896	0.906	0.917	0.927	0.937	0.948	0.958	0.969	0.979	0.989
8	1.000	1.011	1.021	1.032	1.042	1.052	1.063	1.073	1.083			

The regular force employed the year round consists of a superintendent, foreman, clerk, steam roller engineer, three special laborers (one of whom is a teamster), seven teamsters, two barn men and ten laborers. During the construction season and when the town appropriates money for extensive construction, this gang is augmented by the addition of from 30 to 50 laborers and 5 to 15 double teams.

The equipment owned by the town consists of a 12-ton steam roller, eight 2-horse teams with carts and sleds for each team, nine snow plows, two road scrapers, oil distributor, watering cart, sweeper and a Ford extended

TABLE II—DECIMAL EQUIVALENT OF NUMBER OF MEN.

Men.	One day.	Men.	One day.	Men.	One day.	Men.	One day.	Men.	One day.	Men.	One day
1.	1.083	22.	23.832	43.	46.575	1...	.583	22.	12.826	43.	25.069
2.	2.166	23.	24.915	44.	47.658	2...	1.166	23.	13.409	44.	25.652
3.	3.249	24.	25.998	45.	48.741	[illegible]	1.749	24.	13.992	45.	26.235
4.	4.333	25.	27.081	46.	49.824	4..	2.332	25.	14.575	46.	26.818
5.	5.417	26.	28.164	47.	50.907	5..	2.915	26.	15.158	47.	27.401
6.	6.500	27.	29.247	48.	51.990	6..	3.498	27.	15.741	48.	27.984
[illegible]	7.581	28.	30.330	49.	53.073	7..	4.081	28.	16.324	[illegible]	28.567
8.	8.664	29.	31.413	50.	54.156	8..	4.664	29.	16.907	50.	29.150
9.	9.750	30.	32.496	51.	55.239	9..	5.247	30.	17.490	51.	29.733
10.	10.833	31.	33.579	52.	56.322	10..	5.833	31.	18.073	52.	30.316
11.	11.916	32.	34.662	53.	57.405	11	6.413	32.	[illegible]	53.	30.899
12.	[illegible]	33.	[illegible]	54.	58.488	12..	6.996	33.	19.239	54.	31.482
13.	14.082	34.	[illegible]	55.	59.571	13..	7.579	34.	19.822	55.	32.065
14.	15.165	35.	37.911	56.	[illegible]	14..	8.162	35.	20.405	56.	32.648
15.	16.248	36.	38.994	[illegible]	61.737	15..	8.745	[illegible]	20.988	57.	33.231
16.	17.332	37.	40.077	[illegible]	62.820	16..	9.328	37.	21.571	58.	33.814
17.	18.414	38.	41.160	59.	63.903	17..	9.911	38.	22.154	59.	34.397
18.	19.497	39.	42.243	60.	64.903	18..	10.494	39.	22.737	60.	31.980
19.	20.580	40.	43.320			19..	11.077	40	23.320		
20.	21.666	41.	[illegible]			20..	11.660	41.	23.903		
21	22.749	42.	45.492			21..	12.243	42.	24.486		

SUPERINTENDENT'S DAILY REPORT

Weather .. . Day of .... Date ... .

Men and Teams	Days of 8 Hrs.	Street	Location on Street	Men and Teams	Days of 8 Hrs.	Street	Location on Street

Material Received at or Taken from Job	Material or Supplies Received at Barn or Railroad

Description of Work Done

.... Superintendent.

Fig. 1—Form for Superintendent's Daily Report.

truck for the use of the superintendent and for moving men and supplies. This winter four double teams are being dispensed with and a 5-ton auto truck substituted in their place.

In order to be able to present an accurate report to the town each year, as required by law, also to know what the various operations are costing, the following system, the result of three years' experimenting, has been worked out by the writer and is giving very satisfactory results:

The town work is limited by law to 48 hours in one week, and in order to secure as much work as possible from the teams this department works 8 hours and 40 minutes a day for five days and 4 hours and 40 minutes on Saturday. This means that in keeping time and distributing the charges to the various classes of work, considerable inconvenience will be encountered due to the odd minutes. To simplify this work Table I was made up. This table gives the hours and minutes in decimal parts of an 8-hour day as low as 5 minutes. Printed on a small card it can be attached to a note or time-book, so that the person checking the time on the job easily changes hours and minutes directly into decimal parts of an 8-hour day. Using this table it is not necessary to reduce the rate of pay per man to an hourly basis: simply multiply the rate per day by the decimal to find the cost of parts of a day or days. This in itself proves to be an advantage worthy of consideration. For example, if a man is paid $3 per day of 8-hours and he works 3 hours and 40 minutes on a certain piece of work, by referring to Table I we find the decimal equivalent is 0.469, multiplying this by 3 equals $1.41; this is much easier than multiplying 3¾ hours by 37½ ct.

LABOR			MATERIAL			LABOR			MATERIAL		
V. R. Nos.	St. Nos.	Amounts	V. R. Nos.	St. Nos.	Amounts	V. R. Nos.	St. Nos.	Amounts	V. R. Nos.	St. Nos.	Amounts
						Amt. br	t. up				
Am'nts	brt. frd.										
Am'nts	up					Amts.	over				

Fig. 3.

TOWN OF CONCORD
DEPARTMENT ROADS AND BRIDGES
Teamster Ticket

Name .... Date. .. ..

	Received From	Delivered To	Time
Loads { Crushed Stone Dust }			
" Gravel			
" Sand			
" Asphalt			
" Handstone			
" Earth			
" Ashes			
Bags Cement			
Bbls. Oil			
Feet of Pipe { Cast Iron Sewer }			
Miscellaneous			

Fig. 2—Teamster Ticket.

Table II gives the decimal equivalent of the number of men from 1 to 60 for one day of 8 hours and 40 minutes and one day of 4 hours and 40 minutes based on an 8-hour day. This table simplifies the work in the office. For example, 8 men have worked 1 day of 8 hours and 40 minutes, 1 man 3 hours and 25 minutes and 1 man 6 hours and 20 minutes, we have from Table II 9.750 plus from Table I 0.135, which equals 9.885, multiplied by the rate say $2.50 = $24.71. This is easier than multiplying 8 hours and 40 minutes by 9 and adding 1 hour and 5 minutes and multiplying by 31 2/10 ct.

As the organization before mentioned is a small one the writer usually secures the necessary data concerning the number of men and the time they are engaged on the different classes of work, either by observation or interrogating the foreman or special laborers, the latter being working foremen or leaders. This information is turned over to the clerk who makes up a report each day on a blank similar to the one shown as Fig. 1. This report, giving a short history of the work done with location, materials used, etc., is placed on file, all of which is very useful when it is desired to recall something which has been entirely forgotten.

At the end of the week the foreman turns in the time-book to the clerk, he makes up the payroll, takes off the number of man-days from each daily report, carries out the extensions checking the total with the payroll, while the decimals in the table are repeating. The total extensions check to about $1.25 on a $1,000, and in the distribution of time to the different classes of work this is considered accurate enough.

Each teamster in the department and each hired team is given a ticket (Fig. 2) each morning, on which he keeps account of the number of loads, where received, where delivered and the class of material. When he changes from one kind of work to another or from one job to another, he marks the time of changing on the ticket. These tickets are handed to the foreman the next morning, he looks them over to see that they are properly filled out and then gives them to the clerk who incorporates them in the daily report.

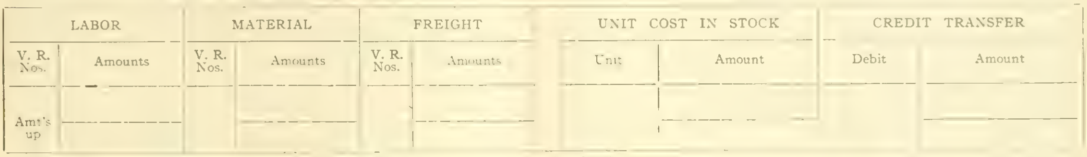
After the time distributions have been totalled and checked with the payroll it is entered on cards (Fig. 3) under the proper headings, the streets being designated by number and the items by letters.

The total payroll is then entered in a ledger and is given a number, this number as well as the number of the month is noted on each card upon which an entry is made, this facilitates checking back on the payroll from the cards if necessary.

The use of cards for the various accounts has the great advantage of being compact and readily accessible and by keeping the distributions posted it is a simple matter to find out the amount of money spent on each class of work to date.

By an inspection of the sample card (Fig. 3) it will be noted that there is a column for material as well as labor. Each bill for material is charged first in the ledger, being given a number in the order in which it is received during the month, the numbers starting at one at the beginning of each month. The bill is then entered on the cards in the same manner as the payroll, using the number of the bill and the number of the month.

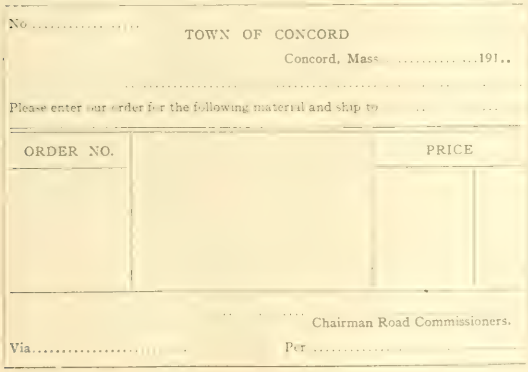
A sample stock card is shown in Fig. 4. All material purchased for general use, such as oil for patching macadam streets, cement, etc., which cannot be charged directly to any particular job is charged to stock. The unit cost of the material in stock is worked out and noted in the column with that heading; then as the material is used it is charged to the job and a credit entry is made on the stock card. To some it may seem that a ledger in addition to the cards is unnecessary; it is used in this case because the law requires the Road Commissioners to examine and pass the bills for payment. By using a ledger and stamping the page opposite the end of each lot of bills inspected, with the amount approved, the stamp having a space for the date and for the commissioners to sign their names, a record is made which shows that the bills entered have been properly inspected and passed. Also the money for the department is voted under several headings by the town; by keeping the amounts in the ledger totalled it is an easy matter to determine the balance remaining in each account, while to determine this from the cards would mean the adding of the totals of all the cards.



LABOR		MATERIAL		FREIGHT		UNIT COST IN STOCK		CREDIT TRANSFER	
V. R. Nos.	Amounts	V. R. Nos.	Amounts	V. R. Nos.	Amounts	Unit	Amount	Debit	Amount
Amt's up									

Fig. 4—Stock Card.

All material is purchased on an order, sample of which is shown in Fig. 5, and when the order is telephoned or telegraphed a confirmation is mailed. This system has been criticised as being rather lengthy and entailing too much detail and for those who do not bother to make a detailed or semi-detailed report at the end of the year or do not care to have accurate costs of their work, perhaps this method would be cumbersome. The writer has found it highly satisfactory, having just finished a $30,000 job upon which he was able to make a detailed report in a day or so after the close of the work, giving the unit costs.



No. ....

TOWN OF CONCORD

Concord, Mass. ....191..

Please enter our order for the following material and ship to

ORDER NO.		PRICE

Chairman Road Commissioners.

Via.................... Per ....

Fig. 5—Material Order Card.

From the reports it will be an easy matter to analyze the entire job in order to pick out the good and bad points connected with it. The writer in his report to the board to whom he reports, presents tables showing the amounts in labor and materials expended on different roads and under the various items of work. For construction, the amounts of each item are given; for maintenance, the patching of macadam and gravel roads are shown itemized, the remainder of the work, such as cleaning up streets, removal of snow, cleaning drains and catch basins, etc., is given in a lump sum for labor and one for material, and a summary of the work done giving locations, etc., is written for each class of work.

The writer is of the opinion that details are of just as much importance in municipal accounting as in a corporation, and he knows by experience that the confidence of the thinking public is greatly strengthened by the knowledge that the town or city expenditures are carefully accounted for in a systematic manner.

COUNTY SURVEYOR'S RECORDS.*

For the official record, I decided upon a loose leaf book. To make the book suitable for re-tracement work as well as the subdivision of a section, as contemplated in the statutes, I found it only necessary to have two different plats. As one of the book-makers had already "wished" onto me a fixed leaf volume designed for subdivision records, in preparing the form for the loose leaf volume I omitted the section plat 8 in. to the mile.

I had a quantity of loose leaf pages prepared as follows: First, a leaf with both pages blank except for caption and marginal ruling. Second, a leaf identical with the first, excepting the addition of a marginal column with the word "Chains" printed at its top. Third, a leaf with its first page as described for the second leaf and its second page ruled and lettered for recording latitudes, departures and closing errors. Fourth, a leaf with the first page containing a section one-inch to the mile plat, 10x10 in. in size, being a township bounded with two rows of sections of each of the contiguous townships.

Below the plat is printed the legend of the different corner signs. The lines of the map are in tint, and the lines of the survey and the corner signs are to be inserted in black. The balance of the page is filled with a blank form for the recording of the final oaths of assistants. The second page of this leaf repeats the blanks for final oaths, and concludes with the Surveyor's Certificate. This printing required five different forms for the four leaves, and to complete the book for subdivision work one more leaf carrying the plat of a section 8 in. to the mile should be added. But as I have not as yet, in 3 years of constant work, had the opportunity of subdividing a section where no retracement of, and establishment of, exterior corners was not needed I have not felt the need of the plat. In compiling the record of a survey I use as many of these different pages as the nature of the work requires.

The Field Memorandum.—Careful search failed to discover a field memorandum book on sale arranged for recording field memoranda as I believed it should be kept. The best I have been able to find for the work is an ordinary blank book, Demy 8va, $4\frac{3}{4}$x$7\frac{1}{2}$ in. in size, semi-flexible morocco covers, containing 176 pages, put out by McClurg of Chicago.

I use a separate field memorandum book for each township, designating them by number. The townships of Garden county number from 15 to 23 North and the Ranges from 41 to 46 West. The volumes of each township are numbered from one up, consecutively. This number is followed by a dash and the unit digit of the township number, another dash and the unit digit of the number of the range. The dash is used to more easily distinguish the volume numbers from page and other figures appearing in the index without using the distinguishing prefixes. Of course, this number system could not be used in a county where the digit of the town and range number repeat.

The Index.—Realizing any records not well indexed would be of little value, and as the statutes require indexing of both the memorandum and record, I attempted an index system that would be both simple, comprehensive and efficient, and one that would not become cumbersome as records should accumulate.

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*Paper [illegible] County Surveyor, Garden County, Nebraska, [illegible] of the Nebraska Engineering Society.

After study and experiment with different systems, I decided that for the official record index an outline map would be best. The scale of the index map I use is ⅜ in. to the mile, this being the size that will admit the area between two standard lines being placed on one page. It requires three pages for one index map of the county. The maps are in tint, with the township and range marked in tint, and the section numbers in a different tint. The page figures are inserted in black at or near the point on the map described in the record. Such an index would not class as a work of art, but it is convenient. I use three of these index maps. One for retracement and subdivision surveys, one for road surveys, and the third for miscellaneous surveys. By using different colored page figures the same map will index several volumes. In this I do not think I produced anything new, but combined the ideas of several I had seen.

Field Memorandum Index.—Since in my field memorandum I write a daily record of the survey, to devise a suitable and comprehensive index, that would be both simple and efficient, became a puzzling problem. After making several extended re-tracement surveys, some of them making a memoranda filling more than one volume, I made a careful study and analysis of the matter recorded, and found when a section had been completely re-traced, matter had been entered concerning each of its four sides, each of its four section corners, and each of its four quarter section corners on the exterior. Beginning at the northeast corner of the section, and bounding it counterclock wise, I found twelve general subdivisions necessary for classifying the information. I, therefore, set aside the first 36 pages of each field memorandum book for the index of the 36 sections of the township, respectively, and the 37th page for the indexing of matter that could not be grouped under the twelve subdivisions. Later, to index subdivision work, I found it necessary to add a 13th division.

Index Abbreviations.—I divide each page into the respective thirteen divisions and mark with abbreviations as follows:

"NE," meaning section corner at the northeast corner of the section.
"N¼," meaning quarter-section corner on the north side of the section.
"NL," meaning line or boundary on the north side of the section.
"NW," meaning section corner at the northwest corner of the section.
"W¼," meaning quarter-section corner on the west side of the section.
"WL," meaning line or boundary on the west side of the section.
"SW," meaning section corner at the southwest corner of the section.
"S¼," meaning quarter section corner on the south side of the section.
"SL," meaning line or boundary on the south side of the section.
"SE," meaning section corner at the southeast corner of the section.
"E¼," meaning quarter-section corner on the east side of the section.
"EL," meaning line or boundary on the east side of the section.
"INT," meaning mark within the section or subdivision.

By this system, when cross indexed, the matter pertaining to each line and exterior quarter section corner appears on two different pages, and of each section corner on four pages. If a town or range line or corner it appears in two volumes, and if a township corner in the volumes of four different townships.

Should a survey, the purpose of which is to establish a line or corner in a particular township, extend into an adjoining township, or on a town or range line between other townships, the record is all made in the volume pertaining to the purpose of the survey, but those parts affecting the other townships will be indexed in the volumes devoted to those townships. Until work has been initiated in all the townships, it may be that all a township volume will contain will be in its index showing where records affecting it will be found in other volumes.

I have found it advisable not only to use abbreviations for the 13 general subdivisions of a section, but to also use abbreviations for the descriptions of pertaining to these divisions.

So far, I find I have used 87 different abbreviations or combinations of abbreviations. The more common ones are: "R," for random line; "TL," for true line; "D," for bearing or direction; "Ch," for chained distance or length of line; "LPP," for latitude proportional point or the proportional point on an east and west line; "MPP," far meridian proportional point or the proportional point on a north and south line; "GC," for government corner; "PC," for proportional corner, or a corner re-established according to law where a government corner is not found; "LC," for local corner, or any corner not a government corner or a corner not known to be re-established by proportional measurement according to law; "Dis" or "D," for description; "Est," for established; "Per," for perpetuated or the description of the re-marking of the corner or of its establishment; "Sh," for search, or the description of the search for the missing corner; "Ev," for evidence, testimony or information concerning a corner; "W," for witness or the bearing of some point in relation to the corner; "E¼/¼" and "W¼/¼," also "S¼/¼" and "N¼/¼" are, respectively, the east, west, south or north quarter section corner points when within a section, but when on the boundary their position is denoted by the particular line; "SE 1/16" or "SW 1/16" refers to the corner at the center of the southeast or southwest quarter sections of the given section.

I find this system of indexing in the field memorandum works all right as long as not more than two volumes are used in any particular township, but when there are more than that, there should be a special index volume for the township.

Recording in Field Memorandum.—Beyond the oaths of assistants, the sworn evidence and testimony of witnesses, and such other matter where signatures are required, I do not enter matter into the field memorandum while at work in the field. Instead, I provide myself and my chainmen with cheap pencil memorandum books. The chainmen usually keep chain notes and topography, and I supplement them with such additional information as I think proper. I make all notations concerning corners. Memory is not trusted for anything, but the pencil notes I make are very brief and abbreviated, consisting largely of diagrams and sketches. As you are probably aware, the statute requires all notes to be written out in full.

In the evening, or as rapidly as possible when not engaged in field work, which includes stormy days while in the field, I complete the field memorandum from the combined notes of myself and assistants, indexing each day's work as it is written up. By so doing, no hunting through notes or other delay is necessary to find the complete information of what has been done. Very often a corner is not perpetuated until several days after its finding. So far, 35 days is the longest I have been engaged in the field on any one survey. I include writing the field memorandum as field work.

I find that the time otherwise lost in the search for notes more than compensates for the time required in indexing, and when indexed it is available for all time. When I come to compile the Official Record the index is waiting for me with everything at my fingers' ends. No danger of leaving anything out, and no trusting to memory. Perhaps some of you have had the same experience that I have, in having the work on one particular survey suspended, during which period you are engaged in other surveying. Upon going back to the first work it is all out of mind. With a complete field memorandum, fully indexed, there is no uncertainty as to what was done, and no time lost in turning to it.

Cyclometer Attachment for Measuring Trail.—The U. S. Forest Service is using an interesting device for measuring trails in some of the National forests. This consists of the front wheel of a bicycle equipped with a special handle bar so that it can be held firmly in one hand. A cyclometer registering miles and tenths of a mile is attached to the wheel, which is pushed by a ranger.

A Fountain Ruling Pen.—A time-saving ruling pen has been placed on the market by Kolesch & Co., New York City. This is known as the "Designo" fountain ruling pen. It is stated that it can be used with any ink and that one filling is sufficient for a day's work.

OFFICIAL BENCH MARKS OF THE CITY OF PORTLAND, ORE.

The standard bench marks of the city of Portland, Ore., are divided into three classes, based mainly on permanency. Class A bench marks are considered the most permanent. Class B are also considered permanent and accurate but are less substantial and more liable to displacement than Class A. Class C are semi-permanent and are unmarked and are not so easy to identify as the others. In addition to these three classes there are the old street monuments, set at the middle of street intersections. These are designated as "M" and are of about the same order as the Class B. The elevations of all these classes were determined with the same degree of care, but they differ as regards permanency and certainty of identification.

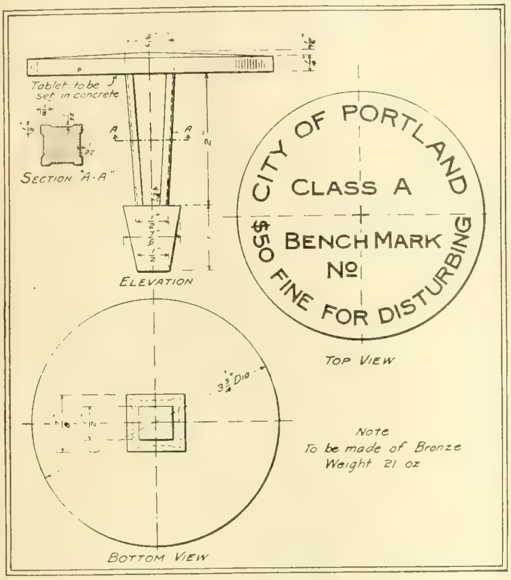

Fig. 1—Standard Class A. Bench Mark.

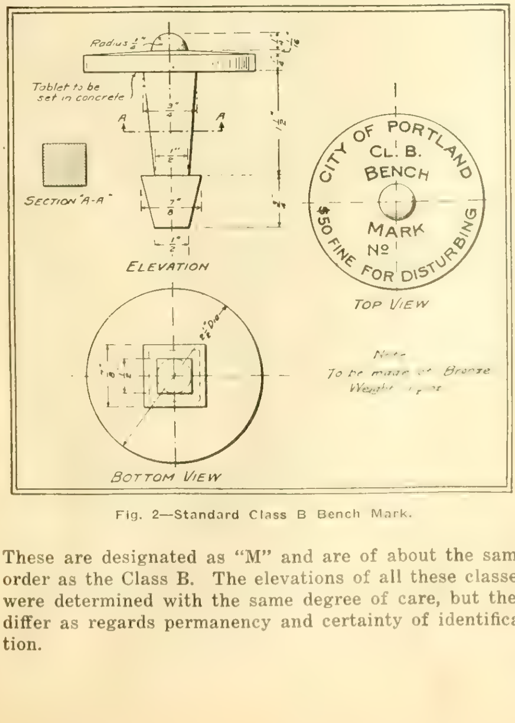

Fig. 2—Standard Class B Bench Mark.

The Class A bench mark is shown in Fig. 1. This consists of either large size bronze tablets or iron pipes set in concrete or a concrete footing. Class B (Fig. 2) includes the smaller bronze tablets and some iron pipes without concrete. Fig. 3 shows the size No. 1 standard bench mark. This is set in concrete, filling hole about 16 in. diameter and 3 ft., making a block of about 4 cu. ft. of 1:2:4 mixture. The standard size No. 2 pipe bench mark is illustrated by Fig. 4. This bench mark is set in a concrete footing extending about 5 in. below base plate and 3 in. above, making approximately 1 cu. ft. of 1:2:4 concrete.

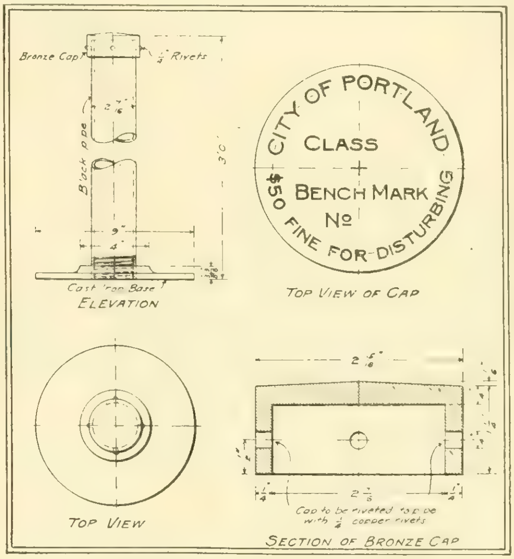

Fig. 3—Plan of Size No. 1 Bench Mark.

The Department of Public Works of Portland has issued recently a 141-page booklet, containing a complete list of the bench marks established on the "Bench Level Survey" of the city, made by the Bureau of Surveys and Drafting between March, 1914, and July, 1915. In this booklet, for convenience of reference, the city is divided into 8 districts, and the bench marks in each district are listed separately. The bench marks in each district are listed by the N. and S. streets as far as possible. The N. and S. streets are taken in succession, usually from the Willamette River outward, and the B.M.'s on each are taken in a certain direction for each district.

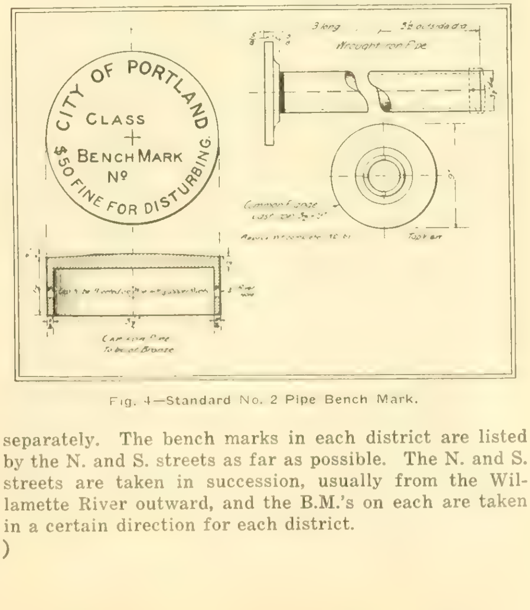

Fig. 4—Standard No. 2 Pipe Bench Mark.

EXHIBITORS AND LOCATIONS OF EXHIBITS AT TENTH CHICAGO CEMENT SHOW, COLISEUM, FEBRUARY 7-15.

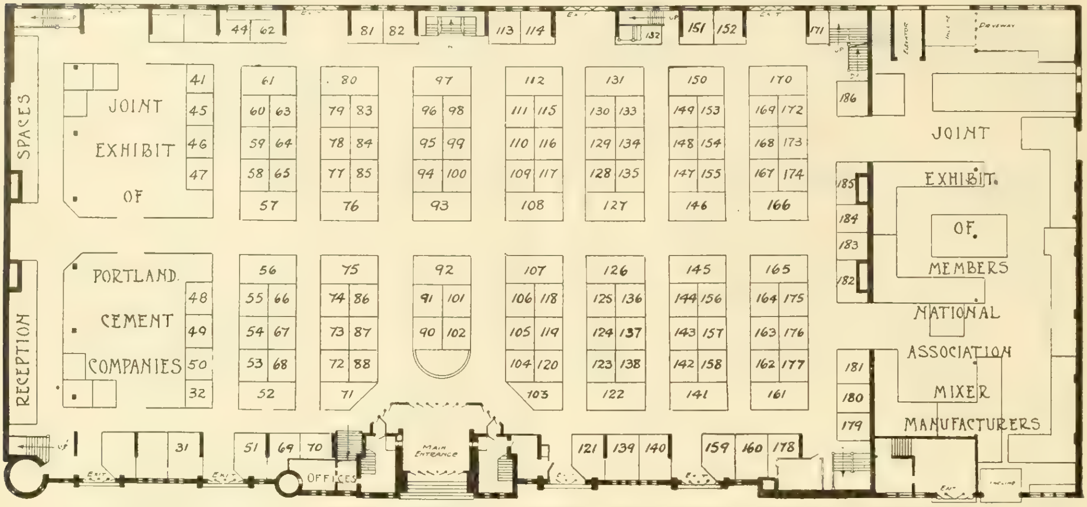

Diagram of Main Floor of Coliseum, Showing Space Numbers. Space Numbers in Balcony Run From 216 to 289.

	Space No.
Abram Cement Tool Co	*275
Amalgamated Roofing Co	154
The American City	*210
The American Contractor Pub. Co	*221
The American Cement Machine Co.	144-145-156
America Dump Wagon Co	*269
American Steel & Wire Co	57
Anti-Hydro Waterproofing Co	*284
Archer Iron Works	87-88
Architectural Mold Co	82
Art Stone Co	71
Atlas Engineering Co	121
The Austin-Western Road Machinery Co.	103
The R. D. Baker Co	58-59
The Baker Manufacturing Co	131
Bates Valve Bag Co	*225
The Baute Concrete Machinery Co	*253
Better Roads and Streets	*228
Blaw Steel Construction Co	126-130-137-138
Blystone Manufacturing Co	104
Brandell Co.	116-117
Brownwall Engine & Pulley Co., Inc	*241
Building Age	*235
Jno. F. Byers Machine Co., The	162
Calumet Steel Co	66
Carbic Mfg. Co	*260
Carey Co., Philip	*239
Carpenter & Co., Geo. B	166
Cement & Engineering News	*281
Cement Era Pub. Co	120
Cement Gun Co., Inc	105
Cement Tile Machinery Co	149-150-153
Ceresit Waterproofing Co	85
C. H. & E. Manufacturing Co., Inc	109-110
Chain Belt Co	†
Chicago Cement Vault Co	*226-227
Clarke Manufacturing Co	*254
Concrete-Cement Age Pub. Co	111
Conlin & Co	*230
Conneaut Shovel Co	*270
Contractor, The	*256
Cornelius Co., H. D	*280
Crown Point Spar Co	*229
D. & A. Post Mold Co	*272-273
Davidan, C. S	*285
Dull Co., Raymond W	51
Dunn Mfg. Co., W. E	123
Elevator Supplies Co., Inc	31
Engineering and Contracting	60
Engineering News	106
Engineering Record	83-84
Eureka Machine Co	139-140
Fair Silo Construction Co	*249
Foote Concrete Machinery Co	†
Ford Manufacturing Co	48
Galion Iron & Manufacturing Co	159
Garden City Sand Co	102-186
Garford Motor Truck Co., Inc	74-75-86
Gemco Manufacturing Co	*232
Gibler Construction Co., B. F	*250
Great Western Mfg. Co	*115
Greer Road Machinery Co	*274
Handy Sack Baler Co	*277
Heltzel Steel Form & Iron Co	141
Hydraulic Pressed Steel Co	52-53-68
Hydro-Stone Co.	49
Ideal Concrete Machinery Co	168-169-170-172-173
Ideal Engine Co	112
Illinois Steel Co	56
Insley Manufacturing Co	*258
Indiana Truck Co	54-67
International Motor Co	157-158
Jaeger Machine Co	146-147-148-155
Jones Streator Boiler Co	78
Kent Machine Co	118-119
Knickerbocker Co.	79-80
Koehring Machine Co.	93-94-95-96-97-98-99-100
La Grange Specialty Co	132
Lakewood Engineering Co	†
Lansing Co.	176-177
Londelius & Sons, C. A	*286
Louden Machinery Co	*237-238
Marsh-Capron Mfg. Co	†
Martin & Bros	*245
Mays & Talley Co	*262
Miller & Miller Co	*282-½-283
Miller, Earle & Miller, Inc	128-129-130
Milwaukee Concrete Mixer Co	†
Monad, The	*S. ½ 248
Multiplex Concrete Machinery Co	69-70
Municipal Engineering & Contracting Co.	†
Municipal Engineering	*268
Municipal Journal	*259
National Association of Mixer Manufacturers	†
National Builder	*287
The "New-Way" Motor Co	122
Northwestern Steel & Iron Work	124-125
Norwalk Mold Co	*240
Novo Engine Co	127-135
Orr & Sembower, Inc	164-165-175
Oshkosh Mfg. Co	161
Peters-Eastman-Greer Co.	101
Pioneer Asphalt Co	*289
Pitt & Quarry	½ *283
Playford Manufacturing Co	*234
Pneumatic Concrete Placing Co	163
Radford Publications	90-91
Ransome Concrete Machinery Co	†
Reichert Manufacturing Co	133-134
Riverbank Studio	92
Road-Maker, The	*243
Rock Products & Building Materials	77
Roos Co., The H. W	171
Ruddock Bucket Co	*257
Salisbury & Co	55
Sasgen Derrick Co	151-152
Sauerman Bros.	179-180-181
Schaefer Mfg. Co	†
Schlueter, M. L	*278
Scofield, Evans & Co	*288
Sellar Supply Co	142
Service Motor Truck Co	167-174
Silo Specialty Mfg. Co	*246
Smith Co., T. L	†
Sonneborn Sons, Inc., L	*276
Standard Paint Co	*252
The Standard Scale & Supply Co	182-183-184-185
Staple Post Mold Co	*233
Sterling Motor Truck Co	108
Studebaker Corporation	*255
Thomas & Armstrong Co	*261
Thomas Elevator Co	160-178
Trussed Concrete Steel Co	76
2-E Flexible Concrete Forms	*279
Universal Crusher Co	72-73
Walter Concrete Machinery Co	*247
Waterloo Cement Machinery Corp	61-63-64
Whitman Agricultural Co	107
Worthington Pump & Machinery Corp	½ of 32, 50

Cement Companies in Joint Exhibit, North End of Main Building.

Aetna Portland Cement Co.
Alpha Portland Cement Co.
Burt Portland Cement Co.
Crescent Portland Cement Co.
Diamond Portland Cement Co.
Dixie Portland Cement Co.
Huron Portland Cement Co.
Ironton Portland Cement Co.
Kosmos Portland Cement Co.
Lehigh Portland Cement Co.
Louisville Cement Co.
Michigan Portland Cement Co.
Newaygo Portland Co.
New Egyptian Portland Cement Co.
Northwestern States Portland Cement Co.
Pearless Portland Cement Co.
Peninsular Portland Cement Co.
Portland Cement Association.
Sandusky Cement Co.
Union Sand & Material Co.
Universal Portland Cement Co.
Wabash Portland Cement Co.
Wolverine Portland Cement Co.
Wyandotte Portland Cement Co.

*Balcony. †Annex.

Roads and Streets Issue
of

Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

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NEED OF ANNUAL INVENTORIES OF ROADS.

No industrial company of considerable size fails to take stock at the end of every fiscal year, so that its balance sheet will give as true a statement of assets and liabilities as can be obtained. No state, county or city in America, so far as we have heard, ever has taken stock of its plant—its roads, streets, sewers, water works, etc. There have been a few—a very few—inventories made of parts of the plant owned by a municipality, and states, but never of the whole plant.

New Jersey has about 9,150 miles of "improved roads," and has expended upon them $100,000,000 to $140,000,000 during the last 25 years. No records exist to show even the gross expenditure for construction and maintenance combined, so it is hopeless to try to ascertain what has been spent for construction alone. Beside the state itself there are six different kinds of governmental organizations in New Jersey—counties (21), townships (235), boroughs (180), villages (4), towns (24), and cities (43). So we have seven types of authority and 504 different governmental units in New Jersey, each of which builds highways, and none of which can tell what it has spent in the building during the last 25 years!

According to Mr. Harry Meixell, Jr., assistant secretary of the Bureau of State Research of the New Jersey State Chamber of Commerce, fully $7,000,000 was spent in New Jersey each year during the last two years for improved roads, and the outlook indicates a greater annual expenditure every year for the next 25 years. Because of lack of proper co-ordination and supervision by skilled experts, a very large part of the expenditure for roads has been wasted, and the waste will continue until the laws are thoroughly rewritten to provide centralization of authority under competent road builders.

Much the same tale would be heard in other states were one in search of it. Thus John H. Lewis, state engineer of Oregon, recently said that while he is himself in charge of the annual expenditure of $235,000 on state roads, there are 105 county commissioners and judges, 35 county surveyors and 862 road supervisors in charge of an annual expenditure of about $5,000,000 on county roads.

With such diversity of governmental organizations often lacking engineering supervision, it is scarcely remarkable that no one is able to tell what is today invested in roads in any state.

It would be well were every state highway department to appraise the cost of reproducing every road in the state, even though the appraisal were only approximate. At the same time the physical condition could be estimated. Then at intervals, preferably a year apart, a reappraisal could be made. Thus the annual increment in money invested in road construction would be ascertainable. By determining the total amount of money spent for road construction and maintenance combined, and from that total subtracting the appraised increment in road construction, the total expended for mere maintenance could be derived. So long as this is not done, no one can tell how much of the present annual outlay on roads goes for upkeep and how much for betterment.

There is not the slightest doubt that if data were thus compiled, the public could more readily be convinced that the present "hit or miss system" is too expensive to countenance any longer. Expressions of opinion, even from unbiased and qualified experts, do not carry the conviction that comparative merit costs money.

POOR CITY PAVEMENTS AS BREEDERS OF DISEASE.

Dwellers in American cities owe to civil engineers a debt that they never can repay—a debt for a service that is rarely thought of now that it has been rendered. We refer to the practical elimination of typhoid fever in all cities that have installed filtration and water treatment plants. Not only were these plants designed by engineers, but engineers, personally and through engineering journals, were the educators who taught the public that it could be protected against typhoid.

The editor recalls some of his own educational work 25 years ago when he moved to a small city where a typhoid epidemic was in progress. He found that, aside from physicians, no one in the city seemed to know the cause of typhoid and the steps to be taken to prevent it. The doctors were strangely silent, so the epidemic had spread and was still spreading, for nearly every family used water from shallow wells. A new waterworks plant had just been built, and its source of supply, a lake, was free from possibility of contamination. The owner of the waterworks did not know the cause of typhoid, but he was quick to spread the knowledge when the writer told him the cause. The epidemic was brought under control as rapidly as people ceased using well water and took their supply from the lake.

Civil engineers all over the country were similarly instrumental in spreading the knowledge that pure water is readily obtainable and that when it is obtained typhoid decreases enormously. It is well for city engineers to remember this bit of sanitary history, and to adopt every means of assisting with propaganda against the "dust nuisance." Read any metropolitan paper on Sunday and note the tabulated causes of deaths during the preceding week. Diseases of the respiratory organs lead all the rest. To a city engineer the significance of this fact should be apparent. "Grip," "colds" in general, pneumonia, tuberculosis and all the respiratory diseases have their origin in germs. These germs, for the most part, come from expectorated matter that falls upon streets, there to dry and be blown about with the dust that every gust of wind or automobile sends upon its deadly journey.

The preventives? As evident and as easy of application as were those that have almost eliminated typhoid. First, people should be taught the danger of spitting on the streets or anywhere except into a handkerchief or other place designed for the purpose. Second, the streets should be washed frequently, the denser the traffic the more frequently the flushing should be.

To apply water effectively in cleaning pavements, it is essential that the surface be smooth and well crowned. This condition is not perfectly fulfilled in 10 per cent of the streets in America, at a safe guess, and it is not even approximately fulfilled in 30 per cent of the streets. In brief, more than two-thirds the streets in American cities need resurfacing if a marked reduction in respiratory diseases is to be effected. This does not mean, of course, that every city is in need of any such overhauling, but it does mean that the average city needs it and needs it badly.

It seems to us that it is the duty of all civil engineers, and of city engineers in particular, to lose no opportunity to spread the gospel of clean streets and therefore of better pavements. It is peculiarly their duty to lead in political movements that will result in changes of city ordinances respecting assessments for street improvements. The antiquated abutting property method of assessment is sufficient in itself to block progress, and there are many other legal obstacles of like nature. But the greatest obstacle of all is public ignorance of the cause and prevention of respiratory diseases.

ROLLING VS. TAMPING OF CONCRETE.

In the days when concrete was required to be moist and not sloppy—days that are likely to return for certain classes of concrete—thorough consolidation by tamping was usually specified. It was discovered, however, that rolling could be substituted for tamping, usually with a saving in cost and an equally good effect, provided that a series of rollers of increasing weights were used.

We believe Mr. Ernest L. Ransome was the first to discover the most effective way of rolling concrete. At any rate, he seems to have been the first to manufacture rollers of graded weights for this purpose.

For pavement bases and floors of buildings, Mr. Ransome used three rollers. The first rolling was done with a roller weighing 290 lb. and having a face 36 in. long, giving a pressure of 8 lb. per in. This was followed with a 375-lb. roller weighing 10.5 lb. per inch. The final rolling was done with a 645-lb. roller having a face 24 in. wide, weighing nearly 27 lb. per inch. Rollers No. 1 and 2 were 36-in. diameter, and roller No. 3 was 30-in. diameter. Two men with these rollers would do the work of a dozen men with tampers.

In building "monolithic brick pavements" on a 2-in. mortar base laid on the subsoil, a roller weighing 3.5 lb. per inch of face is heavy enough to start with, and it is believed by some engineers to be heavy enough to finish with. We doubt, however, whether it is wise not to finish with a heavier roller. Mortar, of course, will not hold its shape under as heavy a roller as will concrete.

A hand roller known as the "Anyweight" is on the market, and it may be loaded with sand up to a weight of 900 lb. on its 30 in. of face, or 30 lb. per inch. A roller of this weight is moved by one man only with great difficulty even on a brick pavement; hence at least two men should be used on the roller. For rolling brick it is believed by some that a roller of 50 lb. per inch should be used, and that it should be mechanically propelled. Here also a word of caution seems necessary: Do not apply the heavy roller until a lighter roller has been used.

Careful experiments with rollers of different weights are badly needed to establish the most effective weights to use under given conditions. Enough is already known, however, to establish the fact that rolling is very much cheaper than hand tamping, and that rolling is effective if properly done.

THE PROGRESS OF HIGHWAY IMPROVEMENT IN NEW YORK STATE.

Scarcely 20 years ago the state of New York made its first appropriation for road improvement—"a miserly little $50,000." Insignificant as this sum was, it served to advertise what is meant by "state aid in road building." Successively larger annual appropriations (totaling $3,000,000) were made until in 1906 the first really important amount was secured—$50,000,000. Six years later another $50,000,000 was voted for state roads. In addition to the $100,000,000 (85 per cent of which has been spent) the counties have provided $35,000,000 more.

With this $138,000,000 the state will have secured 8,500 miles of improved roads, when the remaining 1,500 miles are built with the $15,000,000 still available. From the recent Federal appropriation of $75,000,000, New York state's share will be $8,000,000.

Since the first "state aid" law was passed in 1898, the counties and towns have built, unaided by the state, 9,000 miles of hard roads, of which 5,000 miles are macadam and 4,000 miles are gravel. Thus New York state already has 16,500 miles of hard roads finished, and will soon have 20,000. There are 80,000 miles of roads in the state. We are not too sanguine in looking forward to the time when fully half this mileage will be "hard" every month of the year under any traffic that may come upon it.

Mr. Edwin Duffey, State Highway Commissioner, recently said:

> Because of the great system that we already have our state is filled with tourists during the spring, summer and autumn, coming from every part of the country. When the additional mileage which is contemplated is constructed, and all of the essential gaps are filled, one will be able to reach by improved road every point of attraction, scenic and historical, in the state of New York.
>
> At the same time the state has constantly in mind the fact that the essential feature of road building is to afford market roads generally distributed throughout the entire state. The system contemplated will accomplish this in a very far-reaching way, and at the same time these same roads will lead to all the points of attraction and thus serve commerce on the one hand and the pleasure-seeker on the other.
>
> The value of this wonderful system can hardly be estimated. Assessed valuations in the country are rising; farm properties are increasing in value; life upon the farm has been transformed; markets will be nearer everyone's door; even the general appearance of the countryside, especially in and about farmhouses and buildings, changes almost instantly for the better when the highway nearby is improved. It is a matter of common remark by close observers that such improvement as the state is making in its highways is resulting in a general increase through the country districts of both thrift and energy.

THE INCREASED ANNUAL OUTPUT OF MOTOR VEHICLES AND ITS SIGNIFICANCE.

The year 1916 witnessed the amazing phenomenon of an 80 per cent increase over 1915 in the value of motor cars and trucks produced in America. The total value of the 1916 output of the factories was $1,088,000,000, of which only $167,000,000 was for the 92,000 trucks that were manufactured, and the balance for the 1,526,000 motor cars.

It is estimated that there are now in use 3,500,000 motor vehicles in the United States, of which not more than 10 per cent are trucks. Although it is likely that no year in the future will show an 80 per cent increase in the production of pleasure cars, there is every likelihood that the output of trucks will grow so rapidly that an 80 per cent increase in annual output may soon occur.

On the steam railways of America the investment in the rolling stock devoted to the hauling and switching of freight is five times the investment in passenger equipment, and the ratio of freight train earnings to passenger train earnings is three to one. These ratios give some idea of what is likely to become the ratio between motor truck and motor car investment. Let there be the same vigorous publicity campaign for motor truck use as there has been for motor car use, let roads and streets be rapidly improved to serve the traffic economically, and there is not the slightest doubt that the value of annual output of motor trucks and trailers will soon exceed that of motor cars.

As above stated the value of the motor cars and trucks built in 1916 was $1,088,000,000. During the same year only $250,000,000 was added to the investment in improved roads. Yet the investment of American railway companies in rolling stock is not one-third their investment in the roadway, exclusive of land. When, therefore, we talk of $250,000,000 as if it were a stupendous amount to expend annually for country road improvement, we talk without a sense of proportion. That sum, great as it is, is only one-quarter the sum invested last year in motor cars. To keep pace with the development of the motor car and truck industry, America should be spending fully eight times $250,000,000 every year on improved streets and roads. We have only begun to wake up to what is before us in the building of highways.

EDITORIAL COMMENT.

In 1912 there were 195 American cities of 30,000 or more population, and in them lived nearly thirty million people. In 146 of these cities the cost of municipal government was $33 per capita for 1912, or a total of $907,000,000. How much of this huge sum might have been saved, or expended to better advantage, had these cities been managed by engineers? The per capita debt of these 146 cities was $70, so that annual interest charge must have exceeded $3 per capita.

For comparison with the above it is interesting to know that the per capita cost of the Federal government in 1912 was $10.10, of which slightly less than $1 went for public works, and $1.60 for pensions. The per capita debt of Uncle Sam is $10.77. So if you live in a city of over 30,000 people, you owe $70 for your share of the city plant and nearly $11 for your share of the Federal government plant. If you have a wife and two children you owe $324 for the family's interest in the municipal and Federal plant, besides owing something substantial for the state and county plant.

A hymn that would please every laborer would be: Every day'll be payday by and by. And if it will please them, why postpone the "by and by"? This thought occurred to a contractor who was having trouble holding good men, so he tried the experiment of paying his men every night. Noticing that he was securing and holding the best men, other nearby contractors adopted the plan. It has long been a rule of management that prompt reward for work done instills more energy into the worker. Yet few managers have followed the rule.

The first 20 miles of the Coleman du Pont Road were finished last autumn. Most of it is reinforced concrete, 14.5 ft. wide, 7 in. thick at center and 5 in. at sides. A 1:2:4 mix was used, with different percentages of hydrated lime up to 10 per cent by volume. It was found that as the percentage of hydrated lime was increased, the number of transverse cracks in the concrete was reduced. The reinforcing steel not only did not reduce the number of cracks, but it failed to prevent the cracks from opening up during dry, cold weather. This was true of all long slabs. Cracking in short slabs is reduced by reinforcing, but at the expense of frequent transverse joints that may be more objectionable than the cracks.

The Cleveland Engineering Society is one of the "live ones." When a new mayor was recently elected the society offered its co-operation in selecting suitable men to fill municipal positions requiring technical ability. But the mayor was of the old school of poltics, so he appointed a lawyer as director of public service, a business agent of a waiters' union as director of public utilities and a horseshoer as commissioner of streets. The three B's are thus represented—the bar, the biscuit-shooters, and the blacksmiths. By keeping this fact in the limelight, the engineers of Cleveland may be reasonably certain of a "better deal" for the city next time.

Concrete pavements and walks may be protected in freezing weather by covering with manure. Experiments by the Lewis Institute in Chicago indicate that a 4-in. layer of fresh stable manure will protect concrete from freezing even at 12° F. Concrete thus protected may subsequently disintegrate if liquids leached from the manure come in contact with the concrete, so it is advisable to insert building paper between the concrete and the manure.

The state of Washington will spend $5,000,000 on road work during 1917 and 1918. More than half of this sum will be spent by the counties under the supervision of the state highway commission. Washington, although sparsely settled and extensive in area, bids fair to become noted for its roads.

COMPARATIVE COSTS OF PAVEMENTS.

To the Editor: It may seem unnecessary to you to continue the correspondence in the discussion originated by your editorial comments on Mr. Stern's comparison of different types of roads, because his recent reply has gone entirely outside the subject of these comments.

A careful reading of this paper indicated a departure from the title and his results merely showed relative costs of different kinds of construction, based on so many different original assumptions as, in my opinion, to render of little value the final figures. This was my only point of criticism in my first letter to you.

I had no intention of entering into a discussion as to the advantages of concrete or other types of road. Several inspections that I have made in past years, not only of the Wayne County roads, but of concrete road construction in many other states, have not proved to me that their average life will be 20 years, nor can I see, if your author's assumptions are based on the 6 years from 1910 to date, how he can in any way be certain that this figure is other than a guess. My own experience on concrete roads dates back to 1906, when I built several miles of them in the city of Panama under conditions of favorable climate and light traffic. To the best of my knowledge, these surfaces are still giving good service, but I should hardly care to use their records or those of any others within my knowledge in an attempt to prove that 20 years was to be the average life of all pavements of this class. Instead of answering my contention, he has introduced other assertions to which exception must be taken.

He assumes, first, that the pavements are laid in rural districts near large cities and not subject to injuries by cuts to repair subsurface structures. Recently, I had under my jurisdiction some 150 miles of just such road and was constantly troubled by the frequent opening of the surface for this very purpose. I would like to exhibit one of my roads, only a few miles from New York City, which has been almost hopelessly damaged in the operations of laying a gas main. I found it necessary to install the same system of permit regulation of street openings for county work that was installed under my jurisdiction in the borough of Manhattan.

He also assumes that the units of cost are for the districts immediately near New York, but afterward states that he has averaged figures of New York, Wisconsin and Michigan. What can be the value of such an average? But his most erroneous statement seems to be in the assumption that the type of pavement has been such that it is intended to perpetuate it and renew it with a similar type after it is worn out. If this is the case, what use is a comparison which gives to one class of pavement an additional value over all others as a future foundation for resurfacing in another manner? It is my opinion that a concrete road is a type of great value in its place, but he hardly strengthens his argument for concrete roads when he admits that the base, or foundation, is the important part of any pavement and that this base requires a renewable wearing surface to protect it from destruction.

Finally, I am unable to see any value in giving an average figure for the maintenance of what he calls "waterbound and bituminous macadam." I did not, of course, mean to state that there were not proper definitions for either waterbound or bituminous construction. It is, however, a fact that many variations are possible under these heads. I can only assume that his use of the phrase "waterbound and bituminous macadam" is due to a slip of the pen. It is true, as he states, that there are many asphalt streets in Manhattan and Brooklyn which have been in existence 25 years, and which are still serviceable. It is also true that these pavements have either had practically no traffic or else have been patched to such an extent as to render the claim as to their life valueless. Many of New York's pavements were laid under a 10 or 15-year guarantee, and no records kept of the amount of repair work done during the guarantee period. Several years' familiarity with the records of the Manhattan Bureau of Highways, gave me the opportunity of learning how little value there is in many of these for any present criticism.

Henry Welles Durham.

New York City, Jan. 16, 1917.

FURNISHING CONTRACTOR WITH CEMENT, SAND AND STONE.

To the Editor: Outagamie County, Wisconsin, opened bids Jan. 24 for about $500,000 worth of concrete road contracts. One of the interesting things about this work is that we have contracted not only for the cement, but the necessary sand and gravel or stone has already been contracted for and will be furnished the contractors at the nearest railroad stations.

One of the biggest problems that we had to contend with last year, during which time the contractors furnished their own material, was that road contracts were being held up by the inability to secure material and cars during the busy construction months of June, July, August and September. This year we have just purchased an unloading crane, material has been contracted for, deliveries will start the first of April, and by the first of July we expect to have all the necessary material unloaded in stock piles along the sight of the work, before the car shortage and lack of material becomes noticeable. This will relieve the contractors of all worry as to where and when they can secure material; neither need they worry as to the quality nor demurrage on cars.

Another advantage, it seems to me, is that the county can maintain an inspector at the pit or plant where the material is loaded, and any rejections that are to be made can and will be made at the plant end of the line. Rejections of material, we have found, that are made when the material reaches the site of job, either f. o. b. cars or when hauled to the site of the work, will often tie up a contract for several days. This year we can inspect all of our sand and gravel, some 80,000 cu. yd., with two inspectors, one at each plant, in three months. This inspector will be in constant communication with our office, and each evening will report the cars and their numbers accepted and shipped that day.

It seems to me that by taking the above precautions, cooperating with the contractors in securing and furnishing them material, by having already contracted for and bought 90,000 bbl. of cement and 80,000 cu. yd. of material this early in the season, that we should secure the best of bids and build out roads at a minimum cost to the taxpayers of Outagamie County.

W. J. Driscoll, Secretary,
County-State Road and Bridge Committee.

Appleton, Wis., Jan. 12, 1917.

COST OF ASPHALT REPAIRS AT FORT WAYNE, IND.

Asphalt pavement patching last year in Fort Wayne, Ind., cost 71.64 ct. per square yard, according to the report of W. H. Droge, Superintendent of the municipal asphalt plant. The actual expenditure for repairs to bituminous pavements out of guarantee was $12,008. The yardages were as follows:

Sheet asphalt, surface heater, sq. yd.	9,180
Sheet asphalt, cut out, sq. yd.	6,881
Tarvia X, pavement repairs, sq. yd.	430
Asphalt block pavement, using surface heater and repairing with sheet asphalt mixture, sq. yd.	266

During the season of 1914, repairs were made to a total area of 202,536 sq. yds. of sheet asphalt pavement at a cost of $0.0487 per square yard of pavement area. In 1915, repairs were made to 266,834 sq. yd. of asphalt pavement at a cost of $0.0340 per square yard of pavement area, and in 1916 a total area of 358,884 sq. yd. of various kinds of bituminous pavements was gone over, at a cost of $0.0334 per square yard of pavement of area.

The city owns a 500-sq. yd. Hetherington & Berner asphalt repair plant. Trinidad refined asphalt was used in all mixtures sent out for patchwork, and the same chemical attention was given the mixtures used by the city in repair work as was given in laying a new pavement. An Iroquois surface heater was used extensively.

ENGINEERING METHODS EMPLOYED ON HIGHWAY CONSTRUCTION, WINONA COUNTY, MINNESOTA.

Contributed by H. B. Childs, Engineer in Charge.

Winona County, Minnesota, has now under way the construction of nearly 100 miles of surfaced highways, of various types, gravel, macadam, brick and concrete. The work is all being done by contract with a time limit of two years to complete. The grading is light, the ground rough and hilly and the work badly scattered. Also, in a community where a $500,000 bond issue for road construction has been bitterly fought for over a year by an organization of farmers, it is necessary that the engineer keep an absolutely complete and accurate record of all work done and yardage moved.

As a consequence it was soon discovered that unless some short-cut methods of laying out the grading and of obtaining the earth work quantities were developed, either the engineering cost would be running too high or else the grading costs would be higher than necessary, due to improperly laid out work. In highway work the grade line or the center line can very often be shifted so as to greatly reduce the earth-work quantities without in any way impairing the usefulness of the finished roadway. However, if the field engineer is pushed for time he will pass over many such places, even though he knows they can be improved upon.

I am presenting the methods of field work and computation developed by us during the past season. They have proved more than useful to us and no doubt will be valuable to other engineers.

First, and as usual, a transitline is run, which follows as closely as possible the center line of the finished road to be, placing stakes every 50 ft.

Instead of the ordinary wooden center stake, we use 20-penny nails, to each of which is attached a good-sized flag of red calico. The calico is torn up into strips cut into about 8-in. lengths and impaled one on each nail. These are driven flush with the surface of the ground, are easily seen and can be readily found in the dirt, dust and even mud, for days after they have been placed. Passing vehicles do not displace them. The chain man can carry enough in his pockets for a day's work in the field. They can be driven without difficulty into frost if necessary, and they are considerably less expensive than the wooden variety. A tree, fence post or telephone pole can be blazed and worked with the station number every few hundred feet.

Levels are taken on the center line and profile platted. For instrument work a combination transit and level is used, as the level attachment to a good transit is accurate enough for highway work and the use of the single instrument saves much time and bother in the field work.

The next step is to obtain the transverse sections of the ground. This work is done with a hand level, a wye level being much too slow when rough country is encountered, and an unnecessary refinement. Sections are taken at least every 50 ft. and as much oftener as the shape of the ground warrants. Instead of taking a set of cross-section notes in an ordinary field book, as is generally done, and afterwards platting same on cross-section paper, the rises or falls with distances out are platted directly in a cross-section field book, scale 10 ft. to an inch. This method saves an immense amount of time, since the replatting is all done away with, and is much less liable to error, as the engineer is right on the ground to check himself as he is doing the platting. In taking cross-section notes it is very easy to put down a plus sign instead of a minus, or to leave out or misplace a decimal point, so that when notes are platted the error is either not detected or is almost impossible to correct. In the office these ground lines are immediately inked in, in order to preserve them.

A trial grade line is now laid on the profile, attempting as closely as possible to balance cuts and fills. Road sections are then penciled onto the ground sections in the cross-section book to conform with the trial grade line, using for this purpose transparent celluloid templates cut to the exact shape of the finished roadbed and side slopes.

Cut and fill areas are then computed. Since the sections are on the page of a book it will be found impossible to use a planimeter, but we employ another method which gives results just as fast and also quite as accurate.

The area to be measured is assumed to be divided into several sections, 2 ft. in width each. With the sections platted on a scale 10 ft. to an inch and using an ordinary No. 20 scale the average height of each of these sections is measured, the sum total of which equals the area sought. The summation can be carried along on the scale, commencing the measurement of each section with the scale placed at the summation of all preceding sections. Areas of sections less than 2 ft. in width can be estimated and added onto the total. The error in this method is not large and is compensating. Further refinement can be had by taking average heights of sections 1 ft. in width, using a No. 10 scale, but results do not warrant the additional time required.

3000	2900	2800	2700	2600	2500	2400	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	900	800	700	600	500	400	300	200	100	00	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1620	1566	1512	1458	1404	1350	1296	1242	1188	1134	1080	1026	972	918	864	810	756	702	648	594	540	486	432	378	324	270	216	162	108	54	0	0.00	0.18	0.37	0.56	0.74	0.93	1.11	1.30	1.48	1.67
1621	1567	1513	1459	1405	1351	1297	1243	1189	1135	1081	1027	973	919	865	811	757	703	649	595	541	487	433	379	325	271	217	163	109	55	1	1.85	2.04	2.22	2.41	2.59	2.78	2.96	3.15	3.33	3.52
1622	1568	1514	1460	1406	1352	1298	1244	1190	1136	1082	1028	974	920	866	812	758	704	650	596	542	488	434	380	326	272	218	164	110	56	2	3.70	3.89	4.07	4.26	4.44	4.63	4.82	5.00	5.18	5.37
1623	1569	1515	1461	1407	1353	1299	1245	1191	1137	1083	1029	975	921	867	813	759	705	651	597	543	489	435	381	327	273	219	165	111	57	3	5.56	5.74	5.93	6.11	6.30	6.48	6.67	6.85	7.04	7.22
1624	1570	1516	1462	1408	1354	1300	1246	1192	1138	1084	1030	976	922	868	814	760	706	652	598	544	490	436	382	328	274	220	166	112	58	4	7.41	7.59	7.78	7.96	8.15	8.33	8.52	8.70	8.89	9.07
1625	1571	1517	1463	1409	1355	1301	1247	1193	1139	1085	1031	977	923	869	815	761	707	653	599	545	491	437	383	329	275	221	167	113	59	5	9.26	9.44	9.63	9.81	10.00	10.18	10.37	10.56	10.74	10.93
1626	1572	1518	1464	1410	1356	1302	1248	1194	1140	1086	1032	978	924	870	816	762	708	654	600	546	492	438	384	330	276	222	168	114	60	6	11.11	11.30	11.48	11.67	11.85	12.04	12.22	12.41	12.59	12.78
1627	1573	1519	1465	1411	1357	1303	1249	1195	1141	1087	1033	979	925	871	817	763	709	655	601	547	493	439	385	331	277	223	269	115	61	7	12.96	13.15	13.33	13.52	13.70	13.89	14.07	14.26	14.44	14.63
1628	1574	1520	1466	1412	1358	1304	1250	1196	1142	1088	1034	980	926	872	818	764	710	656	602	548	494	440	386	332	278	224	170	116	62	8	14.82	15.00	15.18	15.37	15.56	15.74	15.93	16.11	16.30	16.48
1629	1575	1521	1467	1413	1359	1305	1251	1197	1143	1089	1035	981	927	873	819	765	711	657	603	549	495	441	387	333	279	225	171	117	63	9	16.67	16.85	17.04	17.22	17.41	17.59	17.78	17.96	18.15	18.33
1630	1576	1522	1468	1414	1360	1306	1252	1198	1144	1090	1036	982	928	874	820	766	712	658	604	550	496	442	388	334	280	226	172	118	64	10	18.52	18.70	18.89	19.07	19.26	19.44	19.63	19.82	20.00	20.18
1631	1577	1523	1469	1415	1361	1307	1253	1199	1145	1091	1037	983	929	875	821	767	713	659	605	551	497	443	389	335	281	227	173	119	65	11	20.37	20.56	20.74	20.93	21.11	21.30	21.48	21.67	21.85	22.04
1632	1578	1524	1470	1416	1362	1308	1254	1200	1146	1092	1038	984	930	876	822	768	714	660	606	552	498	444	390	336	282	228	174	120	66	12	22.22	22.41	22.59	22.78	22.96	23.15	23.33	23.52	23.70	23.89
1633	1579	1525	1471	1417	1363	1309	1255	1201	1147	1093	1039	985	931	877	823	769	715	661	607	553	499	445	391	337	283	229	175	121	67	13	24.07	24.26	24.44	24.63	24.82	25.00	25.18	25.37	25.56	25.74
1634	1580	1526	1472	1418	1364	1310	1256	1202	1148	1094	1040	986	932	878	824	770	716	662	608	554	500	446	392	338	284	230	176	122	68	14	25.93	26.11	26.30	26.48	26.67	26.85	27.04	27.22	27.41	27.59
1635	1581	1527	1473	1419	1365	1311	1257	1203	1149	1095	1041	987	933	979	825	771	717	663	609	555	501	447	393	339	285	231	177	123	69	15	27.78	27.96	28.15	28.33	28.52	28.70	28.89	29.07	29.26	29.44
1636	1582	1528	1474	1420	1366	1312	1258	1204	1150	1096	1042	988	934	880	826	772	718	664	610	556	502	448	394	340	286	232	178	124	70	16	29.63	29.82	30.00	30.18	30.37	30.56	30.74	30.93	31.11	31.30
1637	1583	1529	1475	1421	1367	1313	1259	1205	1151	1097	1043	989	935	881	827	773	719	665	611	557	503	449	395	341	287	233	179	125	71	17	31.48	31.67	31.85	32.04	32.22	32.41	32.59	32.78	32.96	33.15
1638	1584	1530	1476	1422	1368	1414	1260	1206	1152	1098	1044	990	936	882	828	774	720	666	612	558	504	450	396	342	288	234	180	126	72	18	33.33	33.52	33.70	33.89	34.07	34.26	34.44	34.63	34.82	35.00
1639	1585	1531	1477	1423	1369	1315	1261	1207	1153	1099	1045	991	937	883	829	775	721	667	613	559	505	451	397	343	289	235	181	127	73	19	35.18	35.37	35.56	35.74	35.93	36.11	36.30	36.48	36.67	36.85
1640	1586	1532	1478	1424	1370	1316	1262	1208	1154	1100	1046	992	938	884	830	776	722	668	614	560	506	452	398	344	290	236	182	128	74	20	37.04	37.22	37.41	37.59	37.78	37.96	38.15	38.33	38.52	38.70
1641	1587	1533	1479	1425	1371	1317	1263	1209	1155	1101	1047	993	939	885	831	777	723	669	615	561	507	453	399	345	291	237	183	129	75	21	38.89	39.07	39.26	39.44	39.63	39.82	40.00	40.18	40.37	40.56
1642	1588	1534	1480	1426	1372	1318	1264	1210	1156	1102	1048	994	940	886	832	778	724	670	616	562	508	454	400	346	292	238	184	130	76	22	40.74	40.93	41.11	41.30	41.48	41.67	41.85	42.04	42.22	42.41
1643	1589	1535	1481	1427	1373	1319	1265	1211	1157	1103	1049	995	941	887	833	779	725	671	617	563	509	455	401	347	293	239	185	131	77	23	42.59	42.78	42.96	43.15	43.33	43.52	43.70	43.89	44.07	44.26
1644	1590	1536	1482	1428	1374	1320	1266	1212	1158	1104	1050	996	942	888	834	780	726	672	618	564	510	456	402	348	294	240	186	132	78	24	44.44	44.63	44.82	45.00	45.18	45.37	45.56	45.74	45.93	46.11
1645	1591	1537	1483	1429	1375	1321	1267	1213	1159	1105	1051	997	943	889	835	781	727	673	619	565	511	457	403	349	295	241	187	133	79	25	46.30	46.48	46.67	46.85	47.04	47.22	47.41	47.59	47.78	47.96
1646	1592	1538	1484	1430	1376	1322	1268	1214	1160	1106	1052	998	944	890	836	782	728	674	620	566	512	458	404	350	296	242	188	134	80	26	48.15	48.33	48.52	48.70	48.89	49.07	49.26	49.44	49.63	49.82
1647	1593	1539	1485	1431	1377	1523	1269	1215	1161	1107	1053	999	945	891	837	783	729	675	621	567	513	459	405	351	297	243	189	135	81	27	50.00	50.18	50.37	50.56	50.74	50.93	51.11	51.30	51.48	51.67
1648	1594	1540	1486	1432	1378	1324	1270	1216	1162	1108	1054	1000	946	892	838	784	730	676	622	568	514	460	406	352	298	244	190	136	82	28	51.84	52.04	52.22	52.41	52.59	52.78	52.96	53.15	53.33	53.52
1649	1595	1541	1487	1433	1379	1325	1271	1217	1163	1109	1055	1001	947	893	839	785	731	677	623	569	515	461	407	353	299	245	191	137	83	29	53.70	53.89	54.07	54.26	54.44	54.63	54.81	55.00	55.18	55.37
1650	1596	1542	1488	1434	1380	1326	1272	1218	1164	1110	1056	1002	948	894	840	786	732	678	624	570	516	462	408	354	300	246	192	138	84	30	55.56	55.74	55.93	56.11	56.30	56.48	56.67	56.85	57.04	57.22
1651	1597	1543	1489	1435	1381	1327	1273	1219	1165	1111	1057	1003	949	895	841	787	733	679	625	571	517	463	409	355	301	247	193	139	85	31	57.41	57.59	57.78	57.96	58.15	58.33	58.52	58.70	58.89	59.07
1052	1598	1544	1490	1436	1382	1328	1274	1220	1166	1112	1058	1004	950	896	842	788	734	680	626	572	518	464	410	356	302	248	194	140	86	32	59.26	59.44	59.63	59.82	60.00	60.18	60.37	60.56	60.74	60.93
1653	1599	1545	1491	1437	1383	1329	1275	1221	1167	1113	1059	1005	951	897	843	789	735	681	627	573	519	465	411	357	303	249	195	141	87	33	61.11	61.30	61.48	61.67	61.85	62.04	62.22	62.41	62.59	62.78
1654	1600	1546	1492	1438	1384	1330	1276	1222	1168	1114	1060	1006	952	898	844	790	736	682	628	574	520	466	412	358	304	250	196	142	88	34	62.96	63.15	63.33	63.52	63.70	63.89	64.07	64.26	64.44	64.63
1655	1601	1547	1493	1439	1385	1331	1277	1223	1169	1115	1061	1007	953	899	845	791	737	683	629	575	521	467	413	359	305	251	197	143	89	35	64.82	65.00	65.18	65.37	65.56	65.74	65.93	66.11	66.30	66.48
1656	1602	1548	1494	1440	1386	1332	1278	1224	1170	1116	1062	1008	954	900	846	792	738	684	630	576	522	468	414	360	306	252	198	144	90	36	66.67	66.85	67.04	67.22	67.41	67.59	67.78	67.96	68.15	68.33
1657	1603	1549	1495	1441	1387	1333	1279	1225	1171	1117	1063	1009	955	901	847	793	739	685	631	577	523	469	415	361	307	253	199	145	91	37	68.52	68.70	68.89	69.07	69.26	69.44	69.63	69.82	70.00	70.18
1658	1604	1550	1496	1442	1388	1334	1280	1226	1172	1118	1064	1010	956	902	848	794	740	686	632	578	524	470	416	362	308	254	200	146	92	38	70.37	70.56	70.74	70.93	71.11	71.30	71.48	71.67	71.85	72.04
1659	1605	1551	1497	1443	1389	1335	1281	1227	1173	1119	1065	1011	957	903	849	795	741	687	633	579	525	471	417	363	309	255	201	147	93	39	72.22	72.41	72.59	72.78	72.96	73.15	73.33	73.52	73.70	73.89
1660	1606	1552	1498	1444	1390	1336	1282	1228	1174	1120	1066	1012	958	904	850	796	742	688	634	580	526	472	418	364	310	256	202	148	94	40	74.07	74.26	74.44	74.63	74.82	75.00	75.18	75.37	75.56	75.74
1661	1607	1553	1499	1445	1391	1337	1283	1229	1175	1121	1067	1013	959	905	851	797	743	689	635	581	527	473	419	365	311	257	203	149	95	41	75.93	76.11	76.30	76.48	76.67	76.85	77.04	77.22	77.41	77.59
1662	1608	1554	1500	1446	1392	1338	1284	1230	1176	1122	1068	1014	960	906	852	798	744	690	636	582	528	474	420	366	312	258	204	150	96	42	77.78	77.96	78.15	78.33	78.52	78.70	78.89	79.07	79.26	79.44
1663	1609	1555	1501	1447	1393	1339	1285	1231	1177	1123	1069	1015	961	907	853	799	745	691	637	583	529	475	421	367	313	259	205	151	97	43	79.63	79.82	80.00	80.18	80.37	80.56	80.74	80.93	81.11	81.30
1664	1610	1556	1502	1448	1394	1340	1286	1232	1178	1124	1070	1016	962	908	854	800	746	692	638	584	530	476	422	368	314	260	206	152	98	44	81.48	81.67	81.85	82.04	82.22	82.41	82.59	82.78	82.96	83.15
1665	1611	1557	1503	1449	1395	1341	1287	1233	1179	1125	1071	1017	963	909	855	801	747	693	639	585	531	477	423	369	315	261	207	153	99	45	83.33	83.52	83.70	83.89	84.07	84.26	84.44	84.63	84.82	85.00
1066	1612	1558	1504	1450	1396	1342	1288	1234	1180	1126	1072	1018	964	910	856	802	748	694	640	586	532	478	424	370	316	262	208	154	100	46	85.18	85.37	85.56	85.74	85.93	86.11	86.30	86.48	96.67	86.85
1667	1613	1559	1505	1451	1397	1343	1289	1235	1181	1127	1073	1019	965	911	857	803	749	695	641	587	533	479	425	371	317	263	209	155	101	47	87.04	87.22	87.41	87.59	87.78	87.96	88.15	88.33	88.52	88.70
1068	1614	1560	1506	1452	1398	1344	1290	1236	1182	1128	1074	1020	966	912	858	804	750	696	642	588	534	480	426	372	318	264	210	156	102	48	88.89	89.07	89.26	89.44	89.63	89.82	90.00	90.18	90.37	90.56
1669	1615	1561	1507	1453	1399	1345	1291	1237	1183	1129	1075	1021	967	913	859	805	751	697	643	589	535	481	427	373	319	265	211	157	103	49	90.74	90.93	91.11	91.30	91.48	91.67	91.85	92.04	92.22	92.41
1670	1616	1562	1508	1454	1400	1346	1292	1238	1184	1130	1076	1022	968	914	860	806	752	698	644	590	536	482	428	374	320	266	212	158	104	50	92.59	92.78	92.96	93.15	93.33	93.52	93.70	93.89	94.07	94.26
1671	1617	1563	1509	1455	1401	1347	1293	1239	1185	1131	1077	1023	969	915	861	807	753	699	645	591	537	483	429	375	321	267	213	159	105	51	94.44	94.63	94.82	95.00	95.18	95.37	95.56	95.74	95.93	96.11
1672	1618	1564	1510	1456	1402	1548	1294	1240	1186	1132	1078	1024	970	916	862	808	754	700	646	592	538	484	430	376	322	268	214	160	106	52	96.30	96.48	96.67	96.85	97.04	97.22	97.41	97.59	97.78	97.96
1673	1619	1565	1511	1457	1403	1349	1295	1241	1187	1133	1079	1025	971	917	863	809	755	701	647	593	539	485	431	377	323	269	215	161	107	53	98.15	98.33	98.52	98.70	98.89	99.07	99.26	99.44	99.63	99.82
3000	2900	2800	2700	2600	2500	2400	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	900	800	700	600	500	400	300	200	100	00	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9

Fig. 1—Table of Cubic Yards Per 100 Ft.

Example: End areas are 429.2 and 331.6. Sum of end areas equal 760.8. Find 760 in left-hand portion of table under heading 1,400. Follow from 760 across, to right-hand portion of table, under heading 0.8, and we find 8.89 cu. yd. per 100 ft. are sum of 1,400 and 8.89, or 1,408.89. If sum of end areas was 760.0, then the cubic yards per 100 ft. would be the sum of 1,400 and 7.41, as under heading 0.0, or 1,407.41.

I realize that some engineers will claim that the above described method of obtaining areas is rather crude. Taken in comparison with the other steps in arriving at earth-work quantities, however, it compares very favorably as to accuracy. Ordinarily, cross-sections for highway work are very irregular in shape and the cuts and fills are small in comparison with railroad work. To insure a small percentage of error in final quantities, sections should be taken quite close together in very many places. This is much more likely to be done if the field engineer knows that the work of computing areas has been simplified for him.

To obtain quantities we use a table (Fig. 1) from which results can be obtained faster than with any other I have seen or used.

On the first trial grade line it will probably be found that quantities do not balance. By shifting the grade line up or down by changing the rate of grade this desired result can be arrived at, generally the first time, after a little practice. The work of computing areas and quantities has to be all gone over again, but the time is well spent, on account of the reduction of grading costs. Borrow and waste in road work is generally the sign of an improperly laid-out job.

As soon as a grade line is determined upon the engineer stakes the work out in the field, using a hand level.

To summarize, the various steps are as follows:

1. Transit line, run as closely as possible to center line of road to be.
2. Levels, taken on center line, using level attachment to transit.
3. Plat profile.
4. Transverse ground sections, taken every 50 ft. at least, using hand level, platting directly into cross-section book, scale 10 ft. to 1 in.
5. Lay trial grade line on profile.
6. Pencil trial road sections onto inked-in ground sections, using transparent celluloid templates.
7. Compute areas of cuts and fills, using short-cut method described.
8. Compute quantities, using table.
9. Revise grade line if necessary and recompute quantities, till cuts and fills balance.
10. Stake out work in field according to final grade line, using hand level.

As a final step, and as the ground is opened up, the engineer sketches onto the cross-sections the various classifications of earth work, earth, loose rock and solid rock. These are distinguished on the final sections by different colored inks.

Thus we have a complete and accurate record of all quantities, easily arrived at and in a form which is best understood and appreciated by the layman. As long as the engineer works for a corporation he does not have to bother his head much about what the public thinks of his methods, but highway work is far different and he will soon find that the public's wishes must be considered.

PRESENT PRACTICE AND REGULATIONS PERTAINING TO PAVEMENT OPENINGS.

Present practice and regulations of various cities for handling pavement openings were outlined by Arthur H. Blanchard, Consulting Engineer, New York City, in a paper presented Jan. 24 before the Citizens' Street Traffic Committee of Greater New York. In his paper, which is reprinted below practically in full, Prof. Blanchard presents conclusions that should be of interest to municipal authorities:

Administration and Organization.

Present practice in administration and organization governing pavement openings varies from absolutely no control by a city official to a thoroughly organized administration, such as is found in the cities of Cincinnati and Philadelphia, for example. In Cincinnati it is unlawful for any person, firm, corporation or city department, other than the Street and Sewer Repair Department of the Department of Public Service, to make openings unless a permit is obtained. Philadelphia, with its perfected organization of experienced engineers and inspectors under the Permit Division of the Bureau of Highways, has an efficient workable plan of control which is worthy of investigation and duplication.

Lack of knowledge of subsurface structures in the majority of municipalities is recognized by municipal authorities. Recently endeavors have been made in several municipalities to remedy this condition. The practice of the Borough of Brooklyn of New York City, Philadelphia, and Houston, Texas, are cited as examples. In Houston all persons, firms or corporations owning pipes, etc., were required to file with the city, within 90 days after the passage of the ordinance, a map on a scale of 200 ft. to 1 in., which showed the exact location, size and description of its mains, laterals and other subsurface structures; and, furthermore, in each year within 15 days after Jan. 1, a corrected map or set of maps must be filed.

In many cities it has become the practice to post notices on highways to be paved or repaved and to forward such notices to all property owners residing on streets to be improved, and to persons, corporations and city departments who control subsurface structures on such streets. As an example of such notices, that issued by the city of Baltimore is herewith quoted:

> You are hereby notified that the street bounding this property is to be paved with improved pavement and that the work will commence shortly after six weeks subsequent to the date of this notice. All necessary underground construction for installing or repairing gas, water, electric and other surface structures must be done before the street is paved. No permits to cut trenches or to disturb the pavement will be issued. Notice to the above effect has been given by public advertising.

The ordinance of the city of Cincinnati states that no permits will be granted within a period of three years after the construction of pavements except on account of emergencies.

Permits and Payments for Reconstruction.

Practically all municipalities with over 50,000 inhabitants require some form of permit of a person or corporation desiring to make an opening in a pavement. In many cases, however, the securing of a permit is a mere formality, as in the case of one municipality of 250,000 inhabitants, whose ordinance only requires for the permit a payment of $2 and notice in writing to the Commissioner of Public Works that an opening is to be made. On the other hand, several municipalities require compliance with definite and adequate regulations. As an example, the following excerpts from the ordinances of Pittsburgh are mentioned: The application for a permit must contain a complete detailed description covering location, size of openings, nature of substructures, etc.; a bond of $500 for one opening and $2,000 for an indefinite number of openings must be filed; a deposit to cover the cost of repaving must be made.

The amount of deposit required with a permit varies to a remarkable degree. Some municipalities have adopted a logical basis of charging the cost of repaving, plus a certain percentage for inspection and other overhead charges. In the case of the city of Seattle, where all repairs, after the trench is opened, are made by the department men under the direction of the Superintendent of Streets, a deposit is required, based on the following rates: $2.50 for each cubic yard of earth filling; $5 for the first square yard of pavement; $3 per square yard for each additional square yard broken up; upon the basis of a signed statement by the Superintendent of Streets, the City Treasurer pays back unexpended part of deposit, retaining 10 per cent of actual cost for overhead charges; a utility company may, however, deposit $500 for cost of repairing street openings and renewing same as required.

It should be noted that many cities have adopted a schedule of rates of repaving dependent upon the kind of artificial foundation, type of pavement, and the yardage of opening. For example, Schenectady, N. Y., makes the following charges for artificial foundations and pavements: Asphalt, brick or granite block, $10 for the first square yard and $3 for each yard thereafter; for macadam, $3 for the first yard and $1 for each yard thereafter.

In this connection it has been recommended, in the case of Richmond, Va., that the ultimate cost of installation of lateral connections by public utility companies would be materially reduced if all lateral connections, the usefulness of which could be predicted, were made prior to the time when the street was paved or just before a street was repaved.

Backfilling, Artificial Foundations and Repaving.

Great variation is found in the practice of American municipalities with reference to making repairs of openings by city departments, contractors or public utility companies. In some cases all repaving work is done by the permittee. In Albany, for example, public service corporations open, backfill and repave, while in other instances backfilling and repaving is done under the direction of the Commissioner of Public Works. Many municipalities allow the permittee to open and backfill, artificial foundations and pavements being constructed by city departments. In a few instances, as in the case of Seattle, the city does all the work with experienced men, the result being that openings are repaired in an efficient manner and very little trouble results thereafter. It is well to note that the public utility companies of Seattle appreciate having the work done by experienced employes of the municipality, thus relieving them of responsibility in connection with repairs.

Inefficient control and methods of backfilling are the cause of a very large percentage of the troubles arising from pavement openings. Even with the accumulated knowledge and experience now at hand, many municipalities today allow backfilling to be made by the inefficient method of merely shoveling in as much material as the trench will hold. Advanced methods of backfilling are, however, in use in many municipalities where it is required that all material excavated, except rock, shall be placed in the excavation, thoroughly tamped in layers of from 3 to 6 in., or flushed if the materials and other conditions are suitable for this method of compaction.

Houston, Tex., goes a step further and requires that trenches under pavements shall be refilled with well-rammed gravel, broken stone or brickbats, or refilled with tamped earth and covered with a reinforced concrete (1:2:4) slab, which must project 12 in. on each side of the trench and have a depth of 10½ in. for a 2-ft. opening, increasing to 15 in. for a 6-ft. opening.

Ottawa requires the construction, in addition to the regular foundation, of a reinforced cement-concrete subfoundation 4 in. in thickness, which extends back 4 in. on each side of the trench.

In several municipalities it is required that the cement-concrete foundation shall be cut back for 6 in. on all sides of the opening and be replaced by new cement-concrete, thus forming a slab to bridge over the trench.

Conclusions.

Based on observations of practice in many municipalities throughout America and Europe, the following conclusions are submitted as applicable to general conditions found in municipalities throughout the United States:

Administration and Organization.—Pavement openings should be absolutely under the control of the Chief of the Bureau of Highways; all persons, corporations and other city departments being required to secure permits from the Highway Department prior to making openings in pavements, except where emergency conditions require such openings to be made in the interests of public health and welfare.

Notices should be advertised, posted and sent to all interested parties giving ample warning in cases where streets are to be paved or repaved, and containing the provision that charges to the permittee will cover the cost of backfilling but not artificial foundations and pavements. The practice of not allowing pavement openings to be made within a certain period after a pavement is laid is believed not to be in the interest of public progress and is unnecessary if the notice advocated is given and efficient methods of control, backfilling and repaving are adopted.

Plans of subsurface structures on all streets should be compiled and permits should be granted only after accurate and detailed information has been filed pertaining to all details of substructures in connection with the given pavement opening.

Deposits should be required covering cost of backfilling, reconstructing artificial foundations and repaving, which should be based on a schedule of rates dependent upon the character of backfilling, type of artificial foundation, kind of pavement and yardage of the several items. An adequate percentage should be added to the cost of the above items to cover supervision and other overhead charges.

After a permit has been granted excavation should be made by the permittee, and backfilling and repaving done under the supervision of the engineers of the Highway Department and by a flying squadron of experienced men in the employ of the department.

Backfilling and Artificial Foundations.—All material excavated, except rock, should be replaced in the trench and, in the process of backfilling, the material should be thoroughly compacted by hand or mechanical tampers or with the aid of water used sparingly, dependent upon the character of soil and kind of pipes. The wise saying of an old road foreman, that two tampers are required for every shoveler in order to secure satisfactory compaction, should be borne in mind in organizing the flying squadron of experienced laborers.

Except in the case of waterbound gravel and broken stone roads, cement-concrete foundations over trenches should be constructed and such foundations should extend 6 in. beyond each side of the trench and have a depth of not less than 8 in. If the methods outlined above are adopted it is not necessary to postpone repaving, provided climatic conditions are satisfactory for such work.

If temporary repaving is, for any reason, necessary, it is recommended that the backfilling, as above outlined, be carried to the elevation of the top of the artificial foundation and that such materials as small stone blocks, paving bricks laid flat, asphalt block seconds or hot or cold bituminous concrete should be used for a temporary wearing course.

Repaving.—In the process of repaving it is recommended that the old pavement be cut back 3 in. on each side of the new cement-concrete foundation. The adoption of this plan will eliminate planes of weakness and will ensure the practicability of making an efficient bond with the old pavement.

Sidewalks.—The ground beneath sidewalks in municipalities should be kept clear of vaults and other accessories of buildings. The space under sidewalks should be reserved for the possible future installation of pipe systems which would relieve present congestion of subsurface structures in the carriageway and reduce the number of openings made in pavements.

INDUSTRIAL RAILWAYS IN ROAD CONSTRUCTION.

The employment of industrial railways for transporting road material is a comparatively recent development in the highway construction field. In a paper on the "Transportation of Materials for Road Construction in Illinois," presented in the recent course of Highway Engineering at the University of Illinois, Mr. A. D. Thompson, Contracting Engineer, Peoria, Ill., describes the application of this system to road construction. The matter that follows is taken from Mr. Thompson's paper.

The track for these railways is usually 24-in. gage, with 16 or 20-lb. rails and steel or wood ties. The built-up track with steel ties is made in sections 15 ft. long, with five to seven ties per section, to which the rail is fastened by specially designed clamps, and is very advantageous to lay and move, as two men can carry a section which weighs about 270 lb. Lighter rails are some times advocated to lessen the initial expense, and if the cars are pulled by horses or other motive power operated off the track, a rail weight of 16 lb. may be used. With locomotive haul a 20-lb. rail should be the minimum considered, and a 25-lb. rail would result in a large saving of up-keep expense. The built-up sections are held together by rail straps, or a special shoe, which is of great advantage since it is quickly adjusted over the end of the rail, and the bottom of the shoe supports the joint. Switches are provided of the same length as a track section, and can thus be installed at any point on track already laid, with little work. In crossing railroad or interurban tracks, the industrial track is laid over the other track, and the section on the crossing is fastened with a hinged joint so it can be lifted off and drawn to one side.

The cars used in this system are all steel of about 1½ cu. yd. capacity, and weigh about 1,000 lb. The body of the car is usually V-shaped and supported by a frame at each end in such a manner that it can be easily dumped on either side. A simple device locks the body to prevent tipping in transit. The body can also be locked when tipped about half way for convenience in loading with shovels. The frame of the car should be of heavy steel, well braced to render satisfactory service with engine haul.

The motive power of these railways has generally been small steam locomotives, the most successful of which are of special design to distribute the weight and obtain a low center of gravity, as there is considerable tendency to overturn with the narrow track. The ordinary saddle-tank dinkey with a short wheel base can be used, but is not to be recommended, as it causes unusual track repair expense. These special locomotives weigh from seven to nine tons, and are 20 to 30 hp. and have a speed of 8 to 12 miles per hour. It is better to use the larger engines. On grades exceeding 5 per cent these locomotives are not effective and it is necessary to use a geared locomotive which is much heavier and slower. Their speed limit is about 6 miles per hour. Steam locomotives with kerosene fuel, gasoline locomotives and auto trucks have also been utilized for pulling trains in individual cases. Hauling small trains short distances with teams is also a common economic practice.

Numerous advantages are claimed for hauling by industrial railways on contracts of sufficient size to warrant expense of installation. It is affected very little by the character of the soil or the weather. It can be operated on sand, black soil or clay, and if proper drainage is provided, the hauling operations can proceed during wet periods, when it would be impossible to haul by any other method. This regularity of unloading and delivery is a very considerable benefit in reducing the overhead charges and increasing the speed of construction. The subgrade is not injured and materials are kept cleaner. The speed of operation and the large tonnage possible per train recommend this system as particularly economic for long hauls.

The successful operation of an industrial railway outfit requires the transportation of materials in large daily quantity, which can be furnished only by a most efficient unloading plant. To load the train in a minimum time, storage bins with a capacity of more than one train should be provided from which the cars can be loaded during the time the engine is taking coal and water, or a train of extra cars should be provided and loaded between trips. Provision should be made at the loading terminal for furnishing coal and water to the locomotive quickly.

The number and character of cars required on a contract depends on the length of haul, required rate of delivery, methods of construction and kind of power used. If horse power is used, the trains will be smaller and cars may be of lighter construction and weight than with steam power. When the materials are dumped on the grade, a comparatively small outfit may be satisfactory by working day and night hauling gangs.

In the construction of concrete roads many contractors have adopted special mixers and dump cars of properly proportioned materials directly into the loading skip. When this system is used the hauling must be done in a limited time, and the daily progress of the finished work fixes definitely the amount of materials to be hauled per day, as hauling cannot be done when the mixer is not operated. This plan requires about 50 per cent more equipment than if the material is dumped on the grade. Provision should be made for a sufficient number of cars to operate each train with the maximum tonnage the locomotive can pull. Large trains are especially necessary on long hauls. On a track with not to exceed 2 per cent grade, trains of thirty 1½-cu. yd. cars should be operated. One contractor the past season, operated on one part of his work, trains of 48 cars.

The investment necessary in an industrial railway equipment is heavier than for any other power hauling method. Outfits of track, cars and locomotives may be rented, but the character of the equipment and wearing nature of the work require a high basis for rental, and the price for one season is about 40 per cent of the value in addition to freight two ways and heavy repairs after the return of the outfit. The average outfit for use on large contracts in Illinois road construction should provide for about 5 miles of track. On this basis the following is an estimate of the approximate cost with the present prices of materials of such an outfit if purchased and the rental price for one season:

Cost Price.

5 miles built-up track, 20-lb. rail, at $3,550	$17,750
6 switches at $60	360
4 curves at $60	240
42 1½-yd. cars, without brake, at $125	5,250
8 1½-yd. cars, with brake, at $145	1,160
4 flat cars at $225	900
Locomotive, 30-h.p.	3,300
Total	$28,960

Rental Price, 12 Months.

5 miles built-up track, 20-lb. rail, at $2,165	$10,825
6 switches at $24	144
4 curves at $24	96
42 1½-yd. cars, without brake, at $67	2,814
8 1½-yd. cars, with brake, at $81	648
4 flat cars at $90	360
Locomotive, 30-hp.	1,500
Freight two ways	1,800
Probable repairs	500
Total	$18,687

The operating cost is estimated by the manufacturers at $12 per day, including engineer, brakeman, coal and oil.

The cost of constructing, maintaining and operating an industrial railway system is generally estimated much below the necessary expense. The prospective purchaser is informed that sectional track in 15-ft. lengths can be laid and connected for $25 per mile, that it will cost a few dollars per day for operation, including labor, fuel and oil; that one engine will haul a certain number of cars holding their maximum capacity each trip, and, traveling at a certain maximum rate, a given number of trips will be made daily. Costs based on such assumptions are very misleading, and a short period of actual use will prove the impossibility of obtaining ideal conditions in construction operations.

It may be possible under the most favorable circumstances to lay track for $25 per mile, but under ordinary working conditions where the wages are high and labor scarce, a set of men cannot be spared to lay track regularly, and it must be done at odd times with inexperienced men. At times the men must work in the mud, which impedes their earnest efforts and there is a certain amount of lost time waiting for bolts, fish plates or rails, so the average cost for track laying will be safer to figure at $100 per mile.

The item of track maintenance is generally considered of trivial importance, but this becomes an expensive feature when operating in Illinois mud. When a track is left in place a sufficient period to lay 5 miles of road, this expense should be figured not less than $50 per mile. Taking up track will also add $25 per mile for each time it is moved. The estimated cost of operating per ton many times fails to consider delays from cars jumping track, slower speed because of wet grade, smaller trains at times because of cars out for repairs, lost time of train crews paid straight time, delays for taking on coal and water, and repairs to engine and cars. In fact, these numerous factors of lost time and additional expense will probably double the cost figures based on perfect conditions. Efficient management is probably more necessary for satisfactory results with this system than with any other hauling method. Dealers in equipment for industrial railways can cite numerous cases of road work where the cost ranges from 8 to 10 ct. per ton mile.

One case cited was an outfit rented by the Illinois State Highway Commission in 1913, including 6 miles of track, cars and locomotives. The longest haul was 6 miles, and the cost of hauling was 9 ct. per yard mile, which included operation, superintendence, rental, track laying and freight to and from destination.

The Eighth Annual Report of the Wayne County, Michigan, Road Commissioners cites a number of cases of hauling cost by industrial railway. Two jobs mentioned were the Eureka Road and Huron River Drive Road. The cost of unloading and laying track, operation, depreciation at 15 per cent, and repairs, was 10½ ct. per ton mile.

Professor Agg's chart gives the cost per ton mile of operation of industrial railway haul based on rate of travel of 10 miles per hour, and 20 tons per train, with 30 minutes lost time loading and unloading, as follows: 1½ mile haul, 10.7 ct.; 3 miles, 7 ct.; 5 miles, 6 ct., and 9 miles, 5.1 ct.

On a small road job in Illinois the past summer this method of haul was used. Cars were hauled by teams and length of haul varied from ¾ mile to 2¾ mile. The cost of hauling was about 19 ct. per ton mile, including operation, laying up track and loading on cars.

CARE OF GRAVEL PITS IN WINTER.

The following suggestions on the care of gravel pits from which road material is secured are taken from the December Service Bulletin of the Iowa Highway Commission:

Cover the surface with a heavy coat of straw. This will keep out the frost and will save much dynamite. Open up the runway, on an easy grade, at the south side of the gravel pit, so that the sun will help with its heat. Back down the runway and load so that the pit is circular and as soon as possible drive into the pit and make a circuit in coming out. Keep the bank caved down from the top, throwing all black dirt and frozen chunks out. Always load from the bottom and clean up as you go.

Keep pushing back the straw as it is necessary to uncover for more material. Cave down the last thing at night and remove all frozen chunks toward the center which cannot be used for road material. Be sure that the walls of the pit are entirely covered with loose material when left for the night or over Sunday. You will have little bother with the frost if these simple directions are carefully carried out.

EFFICIENCY AND ECONOMY OF CONVICT LABOR IN ROAD CONSTRUCTION.

The difficulty of obtaining precise information of the relative efficiency of convicts and free men as road laborers has led to many erroneous conclusions regarding the comparative values of the two classes of labor. Perhaps the most complete data yet published on this subject are given in a bulletin, "Convict Labor for Road Work," issued on Dec. 15 by the U. S. Department of Agriculture. This bulletin was prepared by J. E. Pennybacker, Chief, Division of Road Economics, and H. S. Fairbanks, Highway Engineer, of the U. S. Officer of Public Roads and Rural Engineer, and Dr. W. F. Draper of the U. S. Public Health Service. It represents an exhaustive investigation conducted by the office of Public Roads and Rural Engineering in co-operation with the U. S. Public Health Service during a portion of 1914 and 1915. The notes that follow are abstracted from the above mentioned bulletin.

Estimates of the comparative value of the two classes of labor are not wanting, but in their bearing on the general question of the efficiency of convict labor they serve to confuse rather than to illuminate, for they rate the relative efficiency of the convict at from 50 to 150 per cent of that of free labor.

Because of this extreme variability of the relative efficiency of convict labor and free labor, a study of the causes which bring about a difference in the efficiency of the two would seem to be more profitable than an attempt to indicate by figures the amount of the difference. These causes are of two classes, the first being found in the character of the convicts and free men considered as individuals, and the second in the organization and control of groups of each kind of labor.

Considered as an individual worker, it seems to be generally assumed that the average convict is less efficient than the average free worker. As a class they undoubtedly possess a lower order of intelligence and less initiative, ability, and willingness in the performance of honest work than free laborers. Of course, there are as wide differences in character among convicts as among free men, and many convicts prove themselves to be the equals of the best free laborers. But a larger number, by nature possessed of normal ability, seem to have permitted their faculties to become dulled through long careers of idleness, viciousness, and crime; some are mentally or physically defective, and thus unable to compete on a parity with free labor; and others, abnormally quick and intelligent, are shrewd enough to evolve all sorts of schemes to avoid work which is distasteful to them. While the foregoing remarks are true with respect to convicts as a class, it should be noted that the negro convicts of the South are generally conceded to present an exception to the rule. Other conditions being equal, they are regarded by all those best qualified to judge as more efficient workmen than the available free labor of the same section. The reason for this condition is probably found in the fact that the best classes of negro laborers are not generally obtainable for road work, and that when the negro of criminal tendency falls into the hands of the law he is compelled to live a regular and healthful life, which results in his marked physical improvement, while the fear of punishment produces a respectful attention to the orders of the overseers, and a willingness to do more work than money would induce him to perform.

In certain sections, notably in the South, the convicts are drawn largely from previous occupations involving the performance of a kind of labor similar to that required in road work. On the other hand, prisoners of other sections are derived to a much greater extent from the shops and factories, and far fewer of them from the outdoor occupations.

The second class of causes explaining this difference between free and convict labor includes those factors in the organization of convicts into working groups, in their discipline, and in the means adopted for effecting their security, some of which tend to promote the efficiency of the convict force as compared with the free-labor gang, and others which tend toward relative inefficiency. It is probable that these factors are more important in determining the efficiency or inefficiency of convict labor than is the factor of individual efficiency.

In comparing the economy of convict and free-labor gangs, consideration must be given to the facts that the daily expense of a convict to the state is much less, as a rule, than the daily wage of free labor, and that even though the convicts be actually less efficient than the free laborers, man for man, it is possible that the work of the convict gang may be more productive than the free-labor force at the same cost. This difference between

TABLE I.—COST OF MAINTENANCE OF CONVICT LABOR.

State or County.	Maintenance costs per calendar day										Time of productive laborers lost by					
	Food.	Clothing.	Guarding.	Transportation.	Medical attention and incidentals.	Interest and depreciation of camp structures and equipment.	Per diem.	Total.	Force employed in camp maintenance. %	Maintenance cost of productive laborer per calendar day.	Sickness. %	Sundays and holidays. %	Bad weather. %	Total. %	Maintenance of productive labor per working day.	Daily wage of free labor.
New Jersey:																
State camp No. 1	$0.45	$0.045	$0.433	$0.02	$0.035	$0.124	.....	$1.107	14.0	$1.287	5.0	15.0	7.0	27.0	$1.763	$1.75
State camp No. 2	.21	.075	.431	.01	.046	.093	.....	.865	7.0	.93	1.0	15.0	7.0	23.0	1.208	1.75
Kalamazoo County, Mich.*																
Married men	.50	.01	.....	.005	.015	.02	$1.00	1.55	....	1.55	.5	15.0	7.0	22.5	2.00	2.00
Single men	.50	.01	.....	.005	.015	.02	.20	.75	....	.75	.5	15.0	7.0	22.5	.968	2.00
New Mexico	.253	.068	.053	.102	.043	.043	.....	.562	10.0	.621	.5	15.0	2.0	17.5	.753	2.00
Arizona:																
Guarded camps	.414	.108	.378	.104	.055	.017	.....	1.076	15.0	1.266	3.0	15.0	2.0	20.0	1.582	2.50
Honor camps	.414	.108	.....	.104	.055	.017	.....	.698	16.0	.831	3.0	15.0	2.0	20.0	1.039	2.50
Colorado	.288	.05	.....	.03	.030	.022	.....	.42	17.5	.509	.5	15.0	5.0	20.5	.640	2.25
Utah	.25	.05	.15	.07	.03	.03	.....	.88	9.0	.967	.5	15.0	4.0	19.5	1.186	2.25
Virginia	.095	.032	.148	.009	.064	.041	.....	.389	10.0	.432	3.0	15.0	7.0	25.0	.576	1.25
Texas:																
Smith County honor camp	.315	.019	.....	.025	.002	.03	.25	.641	17.1	.772	.5	15.0	6.0	21.5	.983	2.00
New York State camp	.355	.043	.226	.035	.02	.04	.....	.719	13.0	.826	5.0	15.0	7.0	27.0	1.131	2.00
Washington:																
Honor camps	.404	.132	.....	.06	.035	.04	*.50	.671	12.5	.767	6.0	15.0	8.0	29.0	1.58	2.50
South Carolina:																
Charleston County	.122	.04	.213	.02	.044	.025	.....	.464	15.0	.546	8.0	15.0	5.0	28.0	.76	.75
Richland County	.179	.04	.385	.01	.03	.02	.....	.664	10.0	.738	.5	15.0	5.0	20.5	.928	1.00
Union County	.18	.03	.303	.01	.035	.015	.....	.573	8.0	.623	1.0	15.0	5.0	21.0	.788	1.00
North Carolina:																
Durham County	.30	.011	.283	.005	.03	.02	.....	.649	8.0	.705	1.0	15.0	5.0	21.0	.892	1.25
State Camp	.226	.04	.245	.02	.03	.02	.....	.581	10.0	.645	2.0	15.0	5.0	22.0	.827	1.25
Georgia:																
Fulton County	.195	.11	.174	.01	.012	.04	.....	.541	8.0	.588	.5	15.0	5.0	20.5	.74	1.50
Chatham County	.112	.053	.22	.01	.043	.04	.....	.478	8.0	.52	1.0	15.0	5.0	21.0	.658	1.50
Florida:																
De Soto County	.30	.05	.40	.01	.01	.01	.....	.78	8.0	.868	2.0	15.0	5.0	22.0	1.087	1.50
Osceola County	.28	.116	.32	.02	.05	.02	.....	.806	5.0	.847	1.0	15.0	5.0	21.0	1.085	1.50
Orange County	.40	.062	.153	.01	.025	.025	.....	.675	7.0	.726	2.0	15.0	5.0	22.0	.931	1.50
Alabama:																
Bullock County	.20	.06	.17	.01	.02	.02	.....	.48	10.0	.533	1.0	15.0	5.0	21.0	.675	1.00

*Per diem on working days only.

the cost of maintaining the convict and the wage of the free laborer is the greatest economic advantage of convict labor, and the extent of this advantage in a number of the states is indicated by comparison of columns 9 and 17 of Table I.

The only other important economic advantage of convict labor over free labor is that the force is absolutely dependable so far as numbers are concerned. Plans for work can be made in advance with a sure knowledge that the anticipated number of laborers will be on hand to execute them. There can be no tardiness in the convict camp such as is frequently the fault of free labor, and, furthermore, the regularity of the force enables a competent overseer to develop the maximum efficiency of each man to an extent which is not possible with shifting free labor.

But this latter quality which, in one respect is an advantage, in another is one of the most serious defects of convict labor. The constancy which makes the force dependable in attendance and which permits the overseer to provide each man with the work best suited to him, prevents altering the size of the force with changes in the requirements of the work. The force is constant and must be constantly maintained, whether the work justifies it or not. During the delays incident to the failure of road or quarry machinery, the belated arrival of road material, difficulties in acquiring right of way, the opening of new sources of road surfacing material, high water in quarries or gravel pits, and other unavoidable causes too numerous to mention, the whole or a part of the force must be maintained in relative idleness. On Sundays and holidays and during bad weather the continuous expense of the convict camp goes on. In addition to these losses the sick must be maintained though they are entirely unproductive, and this loss amounts to from 1 to 5 per cent.

The above concerns the losses in the time of the productive labor of the camp, but part of the squad employed in preparing food and maintaining the camp is necessarily always unproductive in units of road work. The proportion of the force so employed varies from 7 to 17 per cent, and the average is about 10 per cent.

Thus taking into account only the losses which can be anticipated with reasonable accuracy and omitting from consideration those which are incident to unavoidable failures in the work, the cost of maintaining one productive road laborer one working day will be found to be from 40 to 50 per cent greater than the maintenance cost per calendar day. Table I contains data relative to the itemized cost of maintenance and the time lost for the above mentioned reasons. In a number of instances the figures given are necessarily estimates because accurate records were not at hand, but it is believed that they are the best estimates obtainable. The effect of the lost time upon the maintenance cost will be apparent at once by comparison of columns 9 and 16.

Aside from the large loss through enforced idleness there are a number of other causes of inefficiency due to the very fact that the laborers are convicts. Among the most important of these is the lack of a sufficient incentive to induce the convict to labor diligently. Even among free laborers the man who works for the pure love of his work is in a decided minority. These thoughts do not animate the convict. He has no fear of losing his position, and he is aware that he will rarely be punished for the small procrastinations which he knows well how to practice. Indeed he is very sure that his guards and keepers expect him to be inefficient in a small way, and that he will not forfeit his good time for any but flagrant violations of the rules or open disobedience to orders. He prefers to work rather than to remain in absolute idleness, but he takes his work as a pastime and seldom permits it to become irksome. He sets his own pace and there is a comparatively small percentage of ambitious workers among free laborers. He frequently feigns sickness to avoid work, and often in such a way as to defy detection. He becomes surly and unruly when worked beyond his will so that his keepers often are forced to lower their standards, in order to avoid the too frequent administration of punishment.

The investigators witnessed an example of this sort in an eastern state, where a squad of convicts engaged in grading was found divided into two gangs of pickers and shovelers, respectively. The shovelers rested while the pickers worked, and vice versa, which amounted to the employment of the entire squad only one-half time. When questioned about this practice the superintendent replied: "It is impossible to work the men economically because they would become dissatisfied and we would have to be sending them back to the penitentiary continually." Corporal punishment is forbidden in this state, hence to administer punishment means to return the men to the penitentiary. Though this is an extreme example, all who have worked convicts know that it is only possible to overwork them by the introduction of actual cruelty into their discipline, and that in general the only men about a convict camp who are likely to be overworked are the foremen and the superintendent.

This lack of incentive may be overcome to a great extent by a system of reward for earnest effort.

Another fact which precludes the possibility of developing the convict squad into as efficient an organization as the free-labor gang is that in the former it is impossible to eliminate completely the incompetent worker. There are differences in ability among convicts as among free laborers, but whereas in the employment of the latter it is possible, by selection, to raise the plane of efficiency of the organization to a high level, the incompetent convicts generally must be carried along with the relatively competent, and the efficiency of the organization suffers by the presence of diseased and crippled convicts, incapable of performing a man's work, and those who, by reason of idleness or self-indulgence prior to conviction, are physically soft and inexperienced. The presence of these undesirables, from a labor standpoint, seriously hampers the development of an efficient organization.

A further source of inefficiency is frequently found in the difficulty of securing superintendents and foremen who combine the qualities of judgment and tact in the management and control of the convicts, and of skill and ability in road construction. The attempt to avoid this difficulty by the employment of two sets of officers frequently is rendered abortive by the creation of friction between the two branches of control. Often the difficulty of securing competent superintendents is increased by the fact that candidates must be acceptable not only from the standpoint of their qualifications as road builders and guards, but also in respect to their political connection, and usually the salaries offered to candidates are so low as not to attract men of a high order of ability. These various difficulties frequently result in the selection of incompetent officials, superintendents, and guards, and such a step is invariably reflected in the low plane of efficiency of the convict force.

Much of the inefficiency of convict work results from the use of guarded convicts upon that type of road, which for its most economical construction requires a very flexible force. The construction of top-soil and sand-clay roads can not be satisfactorily done with gang labor, but requires a force readily divided into small units. In dealing with guarded convicts it has been found that one guard can successfully handle as many as 15 men when the character of the work will permit the organization of squads of that size. Grading, quarrying, and the construction of macadam roads afford such an opportunity, but the less continuous and more widely distributed work on the cheaper road surfaces prevents the use of such large squads. That this factor is of more than mere theoretical interest is evidenced by the records of the Virginia Highway Commission. In this state, where the convict force is managed as well as in any state in the Union and with a lower maintenance cost than in any other state, the records of the cost of road work during the period from 1909 to 1915, inclusive, as given in Table II, show that while the work of grading and the construction of macadam roads were conducted to considerable advantage with convict labor, the convicts employed in the building of gravel roads were able to show only a slightly lower cost per mile than free laborers employed on the same class of work, while the average cost of sand-clay and soil roads was nearly 45 per cent higher. These records confirm the opinion of many engineers and foremen that the use of convict labor on the light work ordinarily carried on by the counties of the southern states is a mistake. In the interest of economy it would be better were all this work done by free labor and the use of convicts confined to heavier construction and grading. But if convicts are to be used at all on such work they should, without doubt, be honor men, who may be organized into a fairly mobile force.

TABLE II.—COMPARATIVE MILEAGE AND COST OF VARIOUS TYPES OF ROAD CONSTRUCTED IN VIRGINIA BY CONVICTS AND BY FREE LABOR.

[Based on 12-ft. width of surface.]

	By convict labor.			By free labor.		
Year.	Miles.	Total cost.	Cost per mile.	Miles.	Total cost.	Cost per mile.
		Macadam Road.				
1909........	45.41	$203,662.85	$4,484.98	18.26	$ 89,050.78	$4,876.82
1910........	53.52	233,314.57	4,359.39	81.25	401,905.83	4,946.53
1911........	56.77	195,671.52	3,446.74	67.90	336,369.88	4,953.90
1912........	48.27	218,589.38	4,528.47	95.57	551,475.04	5,770.38
1913........	91.11	368,570.96	4,045.31	85.87	484,343.59	5,640.42
1914........	69.46	286,655.65	4,126.92	81.13	372,743.46	4,594.40
1915........	76.48	303,110.76	3,963.27	82.83	376,761.99	4,494.36
Total av.	441.02	$1,809,575.69	$4,103.16	512.81	$2,612,650.57	$5,094.77
		Grading.				
1911........	1.60	$ 3,043.30	$1,902.06	71.25	$169,577.77	$2,380.04
1912........	24.34	29,946.12	1,230.33	190.23	618,885.49	3,253.35
1913........	3.73	4,711.97	1,263.26	94.41	178,517.12	1,890.79
1914........	3.32	3,185.82	959.58	141.39	222,151.73	1,573.31
1915........	38.09	69,639.04	1,828.28	173.20	291,379.22	1,682.33
Total av.	71.08	$110,526.25	$1,554.95	670.50	$1,480,844.33	$2,208.57
		Gravel Road.				
1909........	25.20	$32,289.37	$1,281.32	8.86	$11,539.82	$1,302.46
1910........	32.50	39,433.40	1,213.33	49.94	61,066.18	1,222.78
1911........	25.69	29,454.37	1,146.53	66.68	85,098.10	1,276.22
1912........	7.89	11,708.11	1,483.92	59.74	75,475.23	1,263.40
1913........	55.05	67,556.69	1,227.19	64.13	80,780.97	1,259.64
1914........	45.51	74,659.92	1,640.51	71.85	128,801.69	1,792.65
1915........	22.60	41,419.38	1,832.71	103.96	221,083.36	2,126.62
Total av.	214.44	$296,521.24	$1,382.77	425.16	$663,845.35	$1,561.40
		Sand-Clay and Soil Roads.				
1909........	16.91	$ 5,251.48	$310.55	49.57	$ 24,463.59	$493.52
1910........	24.96	17,613.08	705.65	111.01	48,290.23	435.01
1911........	39.92	28,080.65	703.42	174.97	69,629.81	397.95
1912........	90.21	53,811.71	596.51	195.37	83,638.53	428.11
1913........	101.44	69,311.40	683.30	345.60	169,192.43	490.43
1914........	218.90	148,161.37	676.85	479.34	251,676.08	525.04
1915........	174.33	153,064.83	878.02	408.94	227,344.16	555.93
Total av.	666.67	$477,298.02	$715.94	1,764.80	$874,534.83	$495.54

Another very important factor in determining the economy of a convict force is the population of the camp and its adjustment to the work to be done, but it is a factor which is overlooked frequently, with resulting inefficiency and failure. Among the considerations entering into the determination of the most effective size of camp are the character of the work, the size of squad that can be safely handled by a guard or foreman, the number of camp men necessary to prepare food and keep the camp in order, and the nature and convenience of the camp buildings and equipment. A camp whose only operation is grading should not be so large as one which is designed to carry along the grading of a road, quarrying and crushing stone, and surfacing all at the same time; but whatever the work, the size of the camp should be properly proportioned to it, and if the working force be too great or too small inefficiency is sure to follow. Also, it is evident that if one guard or foreman can safely control 10 convicts, a working force composed of any number of men not a multiple of 10 is to a certain extent an uneconomical force, since in that case one guard would have a squad of less than 10. Not less than two men are required to cook and care for even the smallest camp, and no more than two are required for 20 men. Furthermore, the overhead charges for superintendence, engineering, and bookkeeping are but little if any larger for 40 or 50 men than 20, and the per capita cost of these items decreases as the population increases. The maximum limit is reached with the largest population for which the superintendent can assume responsibility successfully. Between the minimum and maximum limits the most effective population, in any case must be determined by trial and observation; but it is likely that under average conditions this will be found to be about 40 or 50 men. In many of the smaller southern counties the number of convicts on hand at one time is not more than 20 who must be employed either efficiently on the roads, or at some less desirable occupation, or else maintained in idleness. Under the present laws, in many of the states this condition must be endured, but it might be remedied by the enactment of laws placing county convicts under state control and employment.

Finally, the employment of short-term men invariably results in ineffective work. Since to harden and instruct the recruit requires, in the qualified judgment of superintendents and foremen, from 30 to 60 days, it is obvious that road work employing misdemeanants of terms averaging less than six months must bear a heavy burden of lost time and ineffective labor.

The foregoing are the principal factors which determine the relative efficiency of convict and free labor. They form a body of conflicting and opposing tendencies the individual weight of which can not be appraised except by study and trial in the particular case at hand. In this statement lies the reason for the continuance of inefficiency in all convict work. For, though the tendencies outlined have been well known, the means of studying the comparative influence of each under particular conditions have not been at hand, owing to the failure of public authorities to preserve adequate record of the amount and cost of work performed and the exact cost of the maintenance of convicts. Because of the apparent cheapness with which convicts are fed, clothed, and housed, officials have been led, through this lack of adequate records, into a false sense of security in regard to the economy of convict labor, and there has been a tendency to condone and overlook lapses from a standard of high efficiency because of a feeling that the margin between the daily cost of convict and free labor was wide enough to allow a certain amount of waste. But a comparison of the costs of maintenance of convicts and the prevailing wages of free labor in the typical cases given in Table I should prove convincingly the need of closer attention to detail in the employment of convicts.

In considering the economic improvements of a system of convict road labor the geographical factor must be kept in mind constantly. The problem in the South is widely different from that of the North, East, and West, and there are minor differences between the conditions in these latter sections. In the South, the human material dealt with is so radically different from that of the other sections that its problems are not to be remedied by means which will apply very well to the other sections. But, as has been shown, the difference is economically in favor of the South because of the character of the previous experience of its prisoners, their greater responsiveness to discipline, and the relative cheapness of their accustomed manner of living. However, in general, it is believed that the interests of economy may be subserved—

First, by strict attention to the cost of maintenance and by honest effort to reduce it to the minimum amount consistent with proper living conditions and discipline; second, by the reduction, so far as possible, of all losses of working time; third, by providing a positive incentive to industry to offset the negative fear of punishment; fourth, by the elimination of politics as a factor in the selection of officials; fifth, by offering to officials such salaries as to command the services of capable men; sixth, by combining the responsibility and authority for the direction of road work and convicts in one person at each camp; seventh, by such a diversification of labor and employment as to provide for the large body of prisoners the kind of work in the performance of which they manifest the greatest ability; eighth, by judicious selection of the work to be performed by convicts; ninth, by the proper adjustment of the size of the force to the requirements of the work and by the formation of camps of economical size; tenth, by adopting a more mechanical kind of work for short-term prisoners, or, if they must be employed at road work, the separation of long and short-term men.

THE CAUSES OF CRACKS IN CEMENT CONCRETE PAVEMENTS.*

The causes of cracking of concrete pavements can best be classified as follows:

(1) Expansion and contraction.
  (a) Change in temperature.
  (b) Change in moisture content.
(2) Ununiform bearing under the slab.
  (a) Frost action.
  (b) Lack of homogeneity in subbase.
  (c) Moisture expansion and shrinkage of the subbase.
(3) Excessive bending stress due to heavy loads and impact.

Expansion and Contraction.

Change in Temperature.—It has been well established by several investigators that concrete expands and contracts as the temperature changes, and the amount of movement equals 0.0000055 in. per inch of length. If a concrete road is built in the summer season when the temperature is 90° F., and the temperature in the following winter falls to 0° F., the concrete must contract an amount equal to $0.0000055 \times 90 = 0.00495$ in. per inch of length. This contraction could do no harm if it were not for the resistance offered by friction between the subbase and the slab. When the concrete contracts the friction at the base resists the contraction, and the amount of tension produced in the concrete is dependent on the amount of friction acting. Friction at the base varies with the kind of base and the degree of roughness, and tests recently made by the author throw some light on the amount of friction that can act at the subbase when the slab expands and contracts.

Friction at the Subbase.

The tests referred to above were made by sliding 2-ft. by 6-ft. by 6-in. concrete slabs along previously prepared subbases. The sliding force was applied by means of a long lever and the magnitude of the force was measured with a carefully calibrated dynamometer. The amount of movement of the slab was read with a Berry strain gage while the load increased slowly and steadily.

As the load was applied the slabs seemed to move very slightly, even at the first application, except where a subbase of large broken stone was used. In this instance a high load was necessary to start the slab in motion, after which it required no more load than some of the other bases. Apparently there does not exist a constant value for the coefficient of friction, for the greater the displacement the greater the force of friction becomes.

The values of the frictional resistance offered at various displacements are given in Table I:

TABLE I—FRICTIONAL RESISTANCE OF CONCRETE ON VARIOUS SUB BASES.

Kind of base.	Movement.	Force.	Coefficient.	Movement.	Force.	Coefficient.	Movement.	Force.	Coefficient.
Level clay	0.001	480	0.55	0.01	1,130	1.30	0.05	1,800	2.07
Uneven clay	0.001	500	0.57	0.01	1,120	1.29	0.05	1,800	2.07
Loam	0.001	300	0.34	0.01	1,030	1.18	0.05	1,800	2.07
Level sand	0.001	600	0.69	0.01	1,080	1.24	0.05	1,200	1.38
¾-in. gravel	0.001	450	0.52	0.01	960	1.10	0.05	1,100	1.26
¾-in. broken stone	0.001	380	0.44	0.01	800	0.92	0.05	950	1.09
3 -in. broken stone	0.001	1,060	1.84	0.01	1,550	1.78	0.05	1,900	2.18

When the slab on the loam base had been slid 0.035 in., the then existing load of 1,600 lb. was released to zero, and the slab recovered 0.017 in. of its motion. From this recovery behavior it is seen that the subbase acts in a somewhat elastic manner, and some of the resistance offered to the expansion and contraction of the slab must be that necessary to deform the subbase. The material of the subbase is far from being perfectly elastic, and it must therefore gradually yield under a slowly applied load, such as would obtain in the expansion and contraction of concrete pavements. Hence it is not at all reasonable to assume that the maximum friction shown in the tests described actually exists in concrete pavements, even where their movement is large. The above tests were made in periods of about 10 minutes each, while the corresponding movements in the road might take days.

Moisture Shrinkage.

When a specimen of concrete is permitted to harden under continually moist conditions it expands slightly; on the other hand, shrinkage takes place when it hardens in a dry atmosphere. The amounts of expansion and contraction are dependent to some extent on the richness of the moisture and also on the thoroughness of the drying. Tests were made with specimens of 1:2:4 and 1:3:6 concrete of very wet and very dry consistency. Several days after hardening they were immersed in water and extensometer readings were made on them at frequent intervals. As long as they were wet they remained expanded, with the maximum expansion of 0.0001 in. per inch of length. After 6 months they were removed from the water and allowed to dry out in the warm, dry air of the laboratory, when they immediately began to contract, reaching an ultimate contraction of 0.0008 in. per inch of length. It must be emphasized, however, that these specimens became exceedingly dry in a very short time after their removal to the air of the laboratory, and probably very much dryer than they could ever become in the road. When specimens are subjected to the everyday wet and dry weather conditions they do not change in length very much due to change in moisture content, because their moisture content does not vary greatly under such conditions. Concrete in the road may, under exceptional conditions, be made to suffer extreme drying, but it is very probable that most concrete roads absorb much water by capillarity from the damp or wet underlying subbase; and, moreover, the water that is absorbed during a period of wet weather does not completely evaporate between successive spells of wet weather. However, there is sufficient evaporation from the surface to cause some shrinkage of concrete in the road, as evidenced by the formation of cracks when road slabs are allowed to dry out too quickly. The maximum amount of shrinkage that concrete can reach is 0.0008 in. per inch in length, but it is probable that, in general, the moisture shrinkage of concrete road slabs does not exceed more than 0.0004 in.

Combined Moisture and Temperature Changes.

It is evident that both moisture and temperature act to cause creeping of the slab in the road, and it must be realized that the relative magnitude of these two effects depends on the range of temperature, on the rainfall and on the drainage of the subbase. In an exceptionally well-drained subbase and in a dry climate the moisture shrinkage of the concrete will be large, and will add to the contraction due to changes of temperature. This shrinkage may amount to 0.0004 in. per inch of length, and if there is a decrease in temperature of 100° F. there will be an additional shrinkage of $100 \times 0.0000055 = 0.00055$ in., or a total shrinkage of 0.00095, or, roughly, 0.001 in. for each inch of length. On the other hand, there may be much moisture in the subbase which will keep the concrete expanded at 0.0001, and the net shrinkage will then equal 0.00055 minus 0.0001, or only 0.00045 in.

The sliding of concrete along the subbase develops frictional resistance of considerable magnitude, and when the tension developed in the concrete due to the forces of friction exceeds the tensile strength of the concrete a crack must form. Let the coefficient of friction be equal to 1.0, and assume the tensile strength of the concrete to be 150 lb. per square inch. Let L equal the distance between cracks, then, in a slab 12 in. wide and 6 in. thick, the stress at rupture equals 72 sq. in. x 150 lb., equals 10,800 lb. This stress must be supplied by the forces of friction acting over the distance between cracks, or $fLw = 72$ sq. in. x 150 lb. per square inch where w equals the weight of the concrete per linear foot. This equation reduced to $1.0L72 = 72 \times 150$ or $L = 150$, the distance between cracks. If $f = 2.0$, then $L = 75$ ft., so that the greater the friction the closer will be the spacing between cracks.

The above calculations indicate the advisability of forming the subbase as smoothly as possible. Of course, the tensile strength of the concrete can not obtain unless the concrete is stretched sufficiently. When 150 lb. per square inch exists in the concrete, each inch is stretched $150/3,000,000 = 0.00005$ in. and it has been shown that the shrinkage due to moisture and temperature change may amount to 0.00095 in., far in excess of the amount required to cause rupture.

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*From a paper by A. T. Goldbeck, Engineer of Tests, U. S. Office of Public Roads and Rural Engineering, presented Dec. 29 before the American Association for the Advancement of Science.

The foregoing considerations are based on mature concrete. When the concrete is only a few days old, the tensile strength is very small indeed, and the modulus of elasticity is likewise low. When but two days old the tensile strength may be as low as 50 lb. per square inch, and the modulus of elasticity in tension may be only 1,000,000. The stretch required to produce rupture is then $50/1,000,000 = 0.00005$. This amount of shrinkage could readily be caused by slight drying out or by a decrease in temperature of only $0.00005/0.0000055 =$ approximately 9° F. A comparatively small decrease in temperature may thus produce cracking in the concrete pavement. If the tensile strength at two days is only 50 lb. per square inch, the distance between cracks, when the concrete contracts sufficiently, will be smaller than it is if the concrete cracks at a later period when it has attained higher strength. Assuming the same value for friction and weight of concrete as before we have

$$
\begin{aligned}
&fLw = 50 \times 72, \text{ or} \\
&1.0 \times L \times 72 = 50 \times 72 \\
&L = 50
\end{aligned}
$$

if the coefficient of friction equals 2.0. There may be times, due to a big fall in temperature just after the concrete has hardened and the tensile strength is exceedingly low, when the cracks will be much closer together than the above figures show. There are often cases when the subbase contains projections and depressionss that greatly add to the frictional resistance offered to sliding and such a subbase aids in the production of cracks at close intervals.

Uniform Bearing Under the Slab.—Irrespective of what may cause lack of uniformity of bearing under the slab, let it be assumed that due to some cause this unequal support exists. As an exaggerated case let it be assumed that the slab is largely supported at its two sides, and acts therefore as a simple beam. Assume a 16-ft. roadway 6 in. thick. The fibre stress in the section of greatest bending moment then equals $S = Mc/I : WL/8 \times 6/bd^2 = 72 \times 16 \times 16 \times 12/8 \times 6/12 \times 36 = 384$ lb. per square inch. This value is close to that of the modulus of rupture of the kind of concrete used in road construction. The dead weight of the pavement alone is thus almost sufficient to cause cracking if the slab is afforded improper support. The same condition would hold if the pavement were unsupported at the sides but fully supported at the center. Add the weight and impact of traffic to increase the bending moment due to dead load and it will be readily seen that under the right conditions of improper subbase support a longitudinal crack is likely to form.

Before considering these conditions producing improper support, let the amount of deflection of the slab at rupture be figured. In a simple beam uniformly loaded, the deflection at the center $D = 5^3/384\ WL^3/EI$. Assuming a 5-in. slab, 16 ft. wide and supported at its sides, the deflection under its own weight equals $5/384\ 72 \times 16\ (16 \times 12)^3/3,000,000 \times 12 \times 6^3/12 = 0.164$ in. The slow yielding or "flow" of concrete acts to increase this figure and might even treble it, thereby making the possible deflection as much as 0.5 in. when the crack forms.

Regarding the causes of unequal bearing, nothing very definite may be said. It is generally recognized that unequal compaction of the subbase due to lack of homogeneity and to ununiform rolling may cause more settlement in some spots than in others, and in many subbases built of old Telford or macadam roads are very likely to lack uniformity. Again the well-known expansive effect of freezing can very readily act with different intensity in different parts of the road, thereby causing more than enough rise to produce cracking. The shrinkage of soils when they dry out and their swelling when moistened is an occurrence of every-day observation, and it is quite possible that the shrinkage of the foundation away from the concrete is sufficient in places to cause great bending stress with the formation of cracks in the concrete. The raising of the subbase in spots need not be more than 0.2 in. to cause cracking and the expansive effect of the frost and the swelling and shrinkage effect of moisture on the subbase may be considerably more than this. The writer now has some experiments in progress to show the effect of freezing and moisture on the vertical movement of the road.

Impact of Traffic.—The weight of traffic serves but to accentuate the stresses due to the other physical causes. Heavy loads on a thin slab or where the bearing is ununiform may cause either transverse or longitudinal cracks and when these loads are applied suddenly or with impact, as is the case with the modern heavy truck and steel-tired trailer, these loads will aid the other causes of cracking, although they may not be severe enough to be effective themselves. Traffic, however, often breaks off the corners of slabs, the load then being concentrated near a point having poor bearing.

In conclusion, it must be emphasized that great effort should be exerted to protect the concrete during its initial stages of hardening. Do not mix it any wetter than necessary to obtain smooth, yet economical construction. Protect it from sudden decrease in temperature and keep it wet for at least two weeks in order to prevent undue shrinkage while the concrete is green. Much attention should be given the subbase, for, as has been pointed out, the friction at the base causes transverse cracks. This friction may be greatly reduced by proper care in the preparation of the subbase and in this way the cracks may be widely distributed if not entirely eliminated. In addition, provide proper drainage to keep the subbase as dry as possible, so that the effect of frost and the settlement due to moisture may be eliminated. Finally, design the slab as to thickness to carry the loads it is supposed to carry, irrespective of whether the subbase offers uniform bearing or not.

STEAM ROLLER ATTACHMENT FOR CUTTING PAVEMENT.

A time and cost-saving method was used by the Stone & Webster Engineering Corp. for removing pavement in connection with a street railway track job in a Texas city. The bitulithic surface to be removed was about 2,000 ft. long and 8 ft. wide. For the job in question two pieces of 3x3-in. angle iron were fitted to one of the wheels of a 10-ton steam roller, one side of the iron being sheared for a cutting edge. Two white lines, 8 ft. apart, were then painted on the pavement, to act as guides for the operation of the roller. As the cutter was placed on one wheel only the steering was not difficult and the weight of the roller drove the angle iron through the pavement. After two cuts had been made, each 2,000 ft. in length, a gang of men rolled the pavement to one side. The device cost $10.

Cutting Arrangement for Attachment to Roller.

METHOD OF RESURFACING GRAVEL ROADS IN ROCK COUNTY, WISCONSIN.

During the past 3 years Rock County, Wisconsin, has resurfaced about 35 miles of gravel roads. The work has been carried out under the direction of Mr. Charles E. Moore, County Highway Commissioner. At the recent Road School at the University of Wisconsin Mr. Moore described the method employed in his county. The matter that follows has been taken from Mr. Moore's paper:

The old grade is first trimmed up, care being taken to open up the gutters and provide for proper drainage, replacing wornout culverts by reinforced concrete culverts wherever needed. The road bed is then staked out according to the center line survey, using two lines of stakes for the purpose, set every 100 ft. and the width of the desired surfacing. Having established the true lines to work to, by means of the stakes, a motor road roller is attached to a scarifier and using four teeth the outer 18 in. of the old gravel surface is scarified. When the old road bed is extremely rough and wavy, the entire road surface is scarified to a depth of 4 to 6 in. A road grader, hauled by a team, is then run over the loosened gravel to true up the road bed for the new surfacing.

A 4 to 6-in. course, depending upon the condition of the old road bed, is ordinarily used. If the road should be so badly rutted as to warrant a deeper course than 6 in. it is best to furrow out and apply the gravel in regular courses as in new work. If at any point the old road is considered too low, instead of furrowing out, the grade should be breasted up and sufficient dirt brought up from the gutters to build retaining shoulders and the gravel deposited between will raise the grade to any desired height.

Having completed the new subgrade it should be thoroughly rolled and is then ready for the surfacing. If the pit run gravel is not fit to be used one of the county's portable crushing plants with gravel conveyor attachment is installed. These outfits have a capacity of 150 cu. yd. per day.

Care should be taken to see that the gravel has the proper binding element so that it will "tie up" properly after being flushed and rolled. In the case of clean cement gravel 10 per cent clay should be supplied as the gravel is fed into the crusher. This percentage can be reduced according to the ratio of binding element in the gravel. This binding element can be judged by making mud pats of the screenings and allowing them to dry. A little experimentation in this way will show what is required. Mr. Moore finds that reddish colored gravel will always set and make a hard road without the addition of clay. It is intended to crush the gravel as fine as a jaw crusher will do it conveniently. A ¼-in. screen is used for the first bin or screenings, and a 2-in. screen for the second or gravel bin. In case it turns out too much screenings due to a large percentage of sand, a wire dust jacket or second screen is placed around the ¼-in. screen to save and carry the small pebbles on into the gravel bin and waste the surplus screenings. If the gravel is dry and comes out too clean, a tin jacket of varying width also is placed around the dust jacket to carry enough of the screenings into the second bin to nicely fill the voids in the gravel, but not enough to make sand pockets when dumped on the road. This makes a combination that works to best advantage under the roller.

After the gravel is spread on the road bed the roller is put to work on it. In the meantime screenings are dumped on the shoulder of the road at intervals of about 25 ft., and these are gradually spread upon the gravel as it is rolled whenever the voids in the gravel are not filled until no gravel appears on the surface, the rolling being kept up until the gravel is thoroughly solidified. It is then ready for flushing. About 300 ft. is flushed at a time, using from three to five tanks of water for the purpose, according to requirements. The water is applied in sufficient quantity to keep the gravel from sticking to the rims of the roller, screenings being again applied wherever the gravel appears on the surface. The road should be rolled until it irons down smooth and is thoroughly packed, care being taken not to roll long causing the gravel to get mushy. If for any reason the process is not successful, the road should be allowed to dry out and the process of flushing and rolling repeated.

After the road is dried out and before opening to traffic an inch or more of screenings should be evenly spread on the surface of the road. The purpose is to supply a cushion or carpet to prevent raveling and to preserve the metal from abrasion. It has been found that by this application of screenings a road can be preserved the first year or longer by the use of a king drag by simply going over the road when it is wet and dragging the screenings back on to the track when they have begun to work off the edge of the road. This process can be kept up with fairly good results until the screenings are worn out. This method of surface treating with screenings may be used economically wherever gravel screenings are obtainable, and is especially good for maturing a gravel road.

The Rock County gravel contains a large percentage of small pebbles and a small percentage of coarse pebbles. It is crushed fine as possible so as to give an even mixture and used crusher run. It is found that the finer the gravel the less it will ravel under automobile traffic.

When using material out of a glacial drift consisting of a conglomerate of gravel, hardheads and light colored clay, the same process as above mentioned is followed. This material does not need to be flushed; it only needs to be rolled when damp. It makes an excellent road, and in the three years Rock County has been testing it out it has given the best results of any material, and it is good even when the percentage of metal is not large.

BRICK PAVEMENT WITH 1-IN. CONCRETE BASE.

A 1-in. concrete base was used in the construction of a brick pavement constructed recently in Stockland Township, Iroquois County, Ill., by the Bishop & Liddell Construction Co., Danville, Ill.

After the subgrade was properly prepared the 1-in. base of 1:2½:4 cement, sand and gravel was placed. The sand was the ordinary torpedo grade and the gravel was what is known as roofing gravel, passing over a ½-in. screen and being retained on a ¼-in. screen. The base was mixed to a consistency which would just run down a 30 per cent grade, then it was struck off with a hand templet in a zig-zag motion.

The brick were laid directly on this base, the laying being kept within 20 ft. of the mixer. This caused the brick to bond to the thin base. The brick were rolled within 6 or 8 ft. of the layers, by a water roller weighing 20 to 25 lb. to the lineal inch, the rolling being made crosswise of the pavement, never length-wise.

The grout filler was placed in three coats, of a 1:1 mixture of cement and what is commonly called builders' sand. The first coat was made to a consistency of cream and was evenly poured around the bricks in such a manner that it went to the bottom of the brick and penetrated to the thin base.

The contractors state that the grouting is the most important part of the procedure and the one upon which the success of this type depends. They add that the grout can be applied with a brush, but the other two coats of grout should be applied with a squeege. The second coat should be applied only after the previous coat is settled, but not set up. The third coat should be the filler left on top of the brick from the other two coats, but, by squeeges, it is placed in the joints flush with the surface of the brick. A very important point in applying the filler is to keep it within at least 100 or 200 ft. of the finished brick, and all coats should be finished at the end of the day's work. The pavement is cured in the usual manner.

The principal object of this thin concrete layer, according to the contractors, is to keep all foreign matter from between the bricks, and thus allow the grout to cement them together in one monolithic slab.

GENERAL PRINCIPLES CONCERNING MATERIALS AND THEIR USE IN STREET PAVING AND ROAD CONSTRUCTION.

A progress report of the Special Committee on "Material for Road Construction and on Standards for Their Test and Use" by the American Society of Civil Engineers was submitted at the annual meeting of the society on Jan. 17. The report is printed in the December Proceedings, Vol. XLII, No. 10, pp. 1611-1642, from which the matter that follows is taken. The committee consists of W. K. Crosby (chairman), Arthur H. Blanchard (secretary), H. K. Bishop, A. W. Dean, N. P. Lewis, C. J. Tilden and G. W. Tillson.

Lines and Grades.—Where the lines of the highway are such as to invite high speed, or at least not to discourage high speed, consideration of the effects of speed of the traffic on the surfacing material must be had, and it is entirely possible that a choice of the material or the methods of using any particular material may be determined by the speed to be expected for the traffic, and thus be related to or connected with the lines itself of the highway.

A choice of the material, or methods of using a particular material, may be affected by the grades as fixed. Certain materials, or results of using materials, for highway surfacings will be unsatisfactory outside of certain limits of grades. Conservative practice has fixed the maximum limits for satisfactory results with grades as follows:

Kind of roadway.	Maximum grade. Per cent.
Gravel	12
Broken stone	12
Bituminous surface	6
Bituminous macadam	8
Bituminous concrete	8
Sheet asphalt	5
Cement concrete	8
Brick (cement grout filler)	6
Brick (bituminous filler)	12
Stone block (cement grout filler)	9
Stone block (bituminous filler)	15
Wood block	4

Width.—The width of the roadway to be built will be determined largely by local circumstances, but in view of the recent, constant and rapid increase of traffic on highways, both in number of vehicles and in size of loads, it will be in the interest of economy for designs of highways to be made with proper consideration of further increase.

Where motor traffic forms a considerable proportion of the total traffic likely to use a highway, the unit width of traffic lines to be considered is 9 or 10 ft., instead of 7 or 8 ft. as heretofore, because of the greater clearance required for the safe passing of the units of such traffic.

Where bituminous pavements are laid, the edges need protection and a sudden transition from the pavement to any softer shoulder material should be avoided by means of extra width, or of cement-concrete or other edges, and such reinforcement of the shoulder material as may be necessary.

The width of roadways of rigid material, such as cement-concrete or vitrified block, should be at least equal to what would be prescribed under local conditions for a less rigid surfacing. The great difference between the firmness of a rigid roadway surfacing and of material frequently available for the shoulders thereto, often makes it necessary, for safety and convenience of traffic, as well as for economy of maintenance, that the rigid surfacing should be built wider than would answer for a more flexible surfacing, such as water-bound macadam, for instance, under the same local conditions.

Too narrow a width of roadway encourages, if it does not compel, concentration of traffic to such an extent as to make frequently unfair demands on what would otherwise be a suitable and efficient material for the surfacing. This may be especially noticeable at abrupt changes in the lines of the highway, where any tendency toward the improper concentration of traffic into too narrow areas should be avoided, as far as possible, by such adjustment or separation of lines, and adjustment of width, of crown, or of slope of the roadway surfacing, as will keep the strains of the surfacing material within reasonable limits for it.

Thickness.—The thickness of the pavement or surfacing, of course, will be dependent largely on its type, but it will also be affected by the presence or absence in the construction of an artificial foundation, and, in fact, on the character and ability of the base on which the surfacing is to rest. Approved practice establishes the limits given in Table I for the extremes of thickness for the various layers of the pavement or road crust.

TABLE I.

Kind of roadway.	Thickness of artificial foundation.* Inches.	Thickness of sand cushion or binder course. Inches.	Thickness of wearing course. Inches.
Gravel	4 to 8	....	2 to 4
Broken stone	3 to 8	....	2 to 3
Bituminous surface	4 to 8	....	¼ to ½
Bituminous macadam	3 to 8	....	2 to 3
Bituminous concrete	3 to 8	....	1½ to 3
Sheet asphalt	5 to 8	1 to 1½	1½ to 2
Cement concrete (one-course)	....	....	5 to 8
Cement concrete (two-course)	4 to 8	....	2
Brick	4 to 8	¾ to 1½	3 to 4
Stone block	5 to 12	1 to 2	2½ to 5
Wood block	5 to 8	½	3½ to 4

*Not including extraordinary provisions such as V drains or sub-base courses.

Although the general practice has been too often perhaps to use mass, for the sake of safety, in the preparation of the pavement, it now appears to be evident that some waste has been incurred in the past in this direction, and that a more scientific determination of the thickness, as well as of many other features of highway work, is possible, without sacrifice of safety and yet with economy. However, in view of the recent, constant and rapid increase of the weight of, and consequently of the strains caused by, the traffic, it will be in the interests of economy for designs of highways to be made with proper consideration of further increases.

Drainage.—The use of any form of pavement or road crust, whether bituminous or non-bituminous, does not relieve the necessity of proper drainage in every case. It is not only necessary to provide for such under-drainage as will place and keep the sub-grade in a condition satisfactorily free from moisture and in a state of suitable efficiency, but it is also necessary to provide and to preserve economically such provisions for surface drainage as will, with the provisions for under-drainge, insure these results fairly permanently. Storm-water coming to the roadway must be carried quickly and rapidly away from it by automatic arrangements to the natural watercourses where it can be disposed of finally. The arrangements referred to and so made, such as inlets, ditches, gutters and culverts, should be designed and placed so as to give the least possible offense to the users of the roadway and the abuttors, and yet be built so as to preserve their integrity and efficiency with the least need for attention and expense under even the most persistently adverse natural conditions. A proper longitudinal grade for ditches and gutters is particularly important, in order that the ill and wide effects of standing water may be avoided. A proper cross-section for ditches is also important, in order that the waterway may not become obstructed by the sliding in of the sides.

As related to drainage, the matter of the crown of the roadway is particularly important. The ideal roadway surface would be flat in cross-section were it not for the necessity of the automatic removal of surface water to the channels where it must be most conveniently carried along. Crowning the roadway tends to concentrate the traffic on the ridge where it is then most comfortable for the travelers, and the amount of crown which will result in this concentration on the ridge varies with the type of pavements. Also, the rate of crown necessary for the proper removal of storm-water to the gutters or ditches varies with the type, and with the provisions to be made for the cleaning and the upkeep of the roadway surface. In the general practice, the amount of crown for the shoulders of an uncurbed roadway has usually been a cross-slope of 1 in. per ft., the shoulders being of the natural earthy material, and this rate is to be recommended for shoulders, except in special cases.

The crown generally used in the construction of broken stone roadways is excessive when bituminous materials are used, and a crown of even ½ in. per ft. should be avoided when a lesser crown can be secured without detriment to the surface drainage.

For the various roadway surfacings, the practice generally observed and to be recommended is as given in Table II.

TABLE II.

Kind of roadway.	Crown recommended Maximum.	Crown recommended Minimum.
Gravel	1 in. to the ft.	½ in. to the ft.
Broken stone	¾ in. to the ft.	½ in. to the ft.
Bituminous surface	½ in. to the ft.	¼ in. to the ft.
Bituminous macadam	½ in. to the ft.	¼ in. to the ft.
Bituminous concrete	½ in. to the ft.	¼ in. to the ft.
Sheet asphalt	¼ in. to the ft.	⅛ in. to the ft.
Cement concrete	⅜ in. to the ft.	¼ in. to the ft.
Brick	⅜ in. to the ft.	⅛ in. to the ft.
Stone block	½ in. to the ft.	¼ in. to the ft.
Wood block	¼ in. to the ft.	⅛ in. to the ft.

Concave pavements of cement-concrete, vitrified block, or stone block may frequently be found advantageous for alleys, and, in such cases, the same rates of slopes in cross-section as those previously given should govern.

Artificial Foundations.—Where the character of the traffic justifies the use of an artificial surfacing, it also demands a correspondingly strong foundation. Whether or not an artificial foundation shall be supplied will depend on the local conditions, but in the selection of the materials and the methods of construction of the artificial foundation, every consideration should first be given to the possibilities for securing the greatest efficiency from the natural foundation. Economy in reference to the roadway will be had from the proper choice of the various materials available for artificial foundations, such as sand, gravel, broken stone and concrete.

In the construction of a concrete foundation, the subgrade should first be properly prepared and its greatest efficiency developed. The thickness of the cement-concrete artificial foundation usually laid is 5 or 6 in., but it may be varied advantageously according to the local conditions between 4 and 12 in. The thickness may be varied sometimes between the center of the roadway and the sides.

The most usual proportions for a cement-concrete foundation have been 1 part cement, 3 parts fine aggregate, and 6 parts coarse aggregate. This standard, however, is empirical rather than scientific, and a more rational proportion in any case should be developed according to the needs and facilities of each case. It may often be desirable to increase the mass in some cases at the expense of unit strength, or to increase the mass for the sake of economy in the more expensive material.

Sub-Grade.—The use of any form of pavement or road crust does not relieve the necessity for the construction of a well-drained, thoroughly compacted, homogeneous and stable sub-grade in every case. Indeed, such improvement of the highway generally attracts heavier traffic and thus increases the stresses on the sub-grade. Even when an artificial foundation is to be constructed on the subgrade, proper attention should be given to the preparation of the latter, in order that the greatest economy may be had in the design and expense for the artificial foundation, and, generally speaking at least, the higher the type and the more expensive the artificial foundation, the greater care should be exercised to develop to the utmost the possibilities of the sub-grade. Uniformity in its composition and compaction, as well as evenness of its surface, is far more important than has apparently been generally considered necessary up to this time, and permanence of all the desirable qualities in the sub-grade is equally important.

Materials.—Having determined the characteristics desirable for the materials to be used in any highway work, their description in the specifications should be concise, clear and precise. Although, in some cases, it may not be possible to specify exactly the characteristics desired, it will be possible to specify that these qualities shall lie between certain exact limits, thus giving a reasonable tolerance to the determination of the quality by test, as well as avoiding uncertainty as to whether or not, in this respect, a quality of a material offered is suitable. The description of a material by using a trade name is permissible only in most unusual cases, and such a description is "equally good to" another similar material should never be used. Qualities of a material or methods of its use should not be left "to the satisfaction of the engineer" or "as determined by, or in, the opinion of the engineer."

Specific tests and such description of the methods of performing each test as will leave no room for doubt as to whether the results of the tests come within the limits of tolerance, should always be expressed either in detail, or by reference to the standards of some reputable authorities.

In this connection the committee wishes to call attention to its previously expressed conclusions, as follows:

The character of the stone to be used may influence the choice of a bituminous material.

Whatever method may be used in any case, it is as essential in bituminous work, as in water-bound construction, that a suitable quality of road metal be used.

By proper selection and use of a bituminous material, injury to property and deleterious effects on animal and vegetable life may be avoided, and also considerable hygienic advantage may result from the use of such materials on the highways.

Whenever comprehensive specifications are to be prepared, so as to admit a variety of types of bituminous materials, separate specifications, as may be necessary, should be prepared for each type.

Joints.—For the ordinary joints in block pavements, the materials and methods of filling should be selected so as to produce not only a surface which will retain to the utmost its imperviousness and the stability of the blocks themselves in place, but also as far as practicable, they should conduce toward evenness of wear of the surface of the pavement. If the blocks are resistant to abrasion, but perhaps inclined to round off at the edges of the upper surface under traffic, such filling of the joints is desirable as will lend additional resistance in the blocks to this rounding off at the joints.

Joint fillers are naturally divided into two main classes—the cement mortar filler and the bituminous filler. As it is desirable to secure a suitable water-proof wearing course for pavements, sand should never be used alone as the joint filler.

As regards the cement mortar joints, the proportions of cement, sand and water will be affected by local conditions. Where the blocks are extremely resistant and the highest quality of results is desired, a 1:1 mix of sand and cement is necessary. Where the blocks are of less resistant material and conditions demand economy, a 1:1 mix of cement and sand may be found satisfactory. Great care is necessary in mixing and applying the mortar or grout. To insure uniformity, there should be a constant agitation of the mix up to the moment of its application, and no more water than is necessary for proper fluidity should be used. Success with joints of this kind is dependent in a large degree on the allowance of ample time for the grout to set thoroughly before the traffic is admitted to the roadway.

A bituminous filler may be preferred to a cement-grout filler, on account of the lower cost of street-opening repairs, the better foothold provided for horses, and the securing of a more resilient, and hence less noisy pavement. On steep grades, where some roughness of surface may be desirable for the sake of affording better foothold for animals, some openness at the top of the joint is desirable, and the bituminous joint fillers may be preferred. With bituminous joint fillers, care must be taken to select materials which will not be too brittle in cold weather and so chip out from joints under traffic, and which will not be so soft in hot weather as to flow out of the joints between the blocks. It is believed, although not yet generally admitted as having been actually proven by experience, that the use of a bituminous mastic for joint filling would be an improvement over the customary practice of using bituminous material alone for this purpose. Great care should be taken with bituminous fillers of any kind to insure the actual filling of the joints between the blocks, and great care must be taken to insure this result.

PROPORTIONS OF INGREDIENTS OF BITUMINOUS MORTARS USED FOR FILLERS.

Bituminous motar fillers for block pavements have been used in the United States since 1913. Such trouble as has been experienced with these fillers is ascribed by Mr. Philip P. Sharples, manager General Tarvia Department. The Barrett Co., in a paper presented Dec. 26 before the American Association for the Advancement of Science, as being due to the fact that an insufficient quantity of sand was originally mixed with the bitumen. His conclusions are: A fine sand gives must better results than a coarse sand, and more of it can be introduced in the mastic. By properly heating and applying, a mastic with equal parts by volume of sand and bitumen, can be forced into the joints of block pavements. For special conditions, special grades of bitumens must be used. Hand mixing is cheaper than machine mixing, and as good. The pouring method should be entirely dispensed with and the flushing and squeegeeing method substituted.

Some interesting points on the use of this filler are brought out in Mr. Sharples' paper, portions of which are given below.

The first work in New York was done in 1913-14. About 100,000 sq. yd. of improved granite block pavement were filled with pitch-sand mastic. While the specifications called for a mixture of the two ingredients in equal proportions by volume, "or as much sand up to that proportion as the pitch will carry," it is probable that the percentage of sand actually present in the mastic was not over 30. And it is likely that in many instances it was far less than that. It is certain that in one or two cases not over 5 per cent of sand was present.

The presence of fine material in any mixture stiffens the mixture, and it was expected that the sand would stiffen the pitch, thus making it more stable in the joints. Accordingly, a pitch of lower melting point than ordinarily used was specified. Where a sufficient quantity of sand was introduced into the mix no trouble was experienced, and the streets today are in excellent condition. But where insufficient sand was incorporated there has been trouble with the pitch running to the gutters in the hot summer weather.

The fault lay in the manner of mixing and applying the filler. Originally the mixture of sand and pitch was made in a small bucket, by stirring with a slotted iron paddle. Each joint was filled individually by pouring from the bucket. Considerable time is taken to fill joints in this way and the sand and pitch tended to separate, so that some joints would be filled with nothing but pitch, and a large quantity of sand would be left in the bottom of the bucket which the workmen would not take the trouble to pour out, but would leave to be mixed in the next lot. The result was that the filler was not uniformly what the specifications called for.

In 1914, in Cleveland, O., a pitch-sand mortar was tried out on brick. It was carefully mixed and carefully poured and the result was very satisfactory. About 40 per cent of sand was the average in the mixture. Shortly after this the joints of a brick-paved alley in Columbus were filled with pitch-sand mastic which was mixed in a concrete mixer. Various percentages of sand were tried, and it was found that 2 parts of sand to 3 of pitch gave the best results from the point of view of application. A half-and-half mixture was too stiff to successfully apply. The sand was not very fine and this accounted for the fact that the half-and-half mixture could not be worked. After a year and a half the joints are all full of the mastic, and the alley is in excellent condition. It should be noted here, however, that on this job the method of pouring the joints was not followed. Instead, the mastic was dumped onto the brick and pushed into the joints with squeegees. This insured the filling of all the joints. It also insured a uniform mastic. There is no opportunity for the sand to settle out of the pitch as there is when the joints are poured individually.

A large yardage in Cleveland at about the same time was used on Medina block, and the Columbus methods were followed. With the wider joints of the Medina block, and a finer sand, it was possible to get a 50:50 mix into the joints even in cold weather. A coal-tar pitch of 117° F. melting point (cube in water) was used, with a fine lake sand. It was found that the melting point was a little too low, and, accordingly, for future work a pitch of 126° F. melting point was used with better results. During the summer of 1916, Waterloo Road was paved with brick and the joints were filled with pitch-sand mastic which for the most part consisted of 60 parts sand and 40 parts pitch. This mixture was rather stiff and hard to work, so that an undue amount of filler was left on the surface.

While this work was going on in Cleveland and contiguous territory, New York was trying the experiment of an asphalt-sand mastic. The difficulty of obtaining a good mixture of sand and asphalt was even more pronounced than when pitch was used. Records indicate that sometimes as little as 2 per cent of sand was found in samples taken at random from joints. These streets, however, present a very good appearance on the surface, and owing to the higher melting point of the asphalt no trouble has been experienced from running to the gutters. Openings show, however, that the joints are not as well filled as with coal tar pitch and that the asphalt has not adhered very well to the blocks. In 1916 permission was given the contractors to follow the Columbus method of flushing the mastic on the pavement and then forcing it into the joints with squeegees, hoes or shovels. This has resulted in very much better work. A satisfactory mastic can be made and applied with a minimum of delay. There can be but little separation of the materials.

It is essential that all conditions be known before a specification for any particular location be drawn. A very successful application of pitch-sand mastic was made in Englewood, N. J., on a street which has a grade of 14 per cent and is paved with improved granite block. The pitch in this instance was 145° F. melting point, and a mixture of 50 parts of sand with 50 parts of pitch was applied. The flushing and squeegeeing method was followed. No separation of materials took place, and no running of the mastic has been observed, although the street has been exposed to the hot sun. Owing to the grade and the nature of the traffic, it was deemed advisable to use a pitch of high melting point. The results have justified the departure from the usual specifications.

From observation in various parts of the country the conclusion is reached that not more than 50 parts of sand by volume can be mixed with the same amount of bitumen and secure an economical job. Further, if the work is carried on in very cold weather, not over 40 per cent of sand can be used. Not even this proportion can be used in every kind of weather when the pouring method of filling joints is employed. Further, it is only with sand, all of which will pass a 20-mesh sieve, that a half-and-half mixture can be obtained that will work into the joints.

While numerous attempts have been made to construct machines that will mix the materials, hand mixing still seems to be the best and cheapest method. The mixing may take place in a wheelbarrow, or preferably in a two-wheeled concrete carrying cart, and the best implement for mixing is a large hoe. The mastic can be wheeled immediately to the point of application, may be given an additional tempering with the hoe, and is then poured onto the pavement and immediately pushed into the joints. Concrete mixers have been used for mixing, but their operation is not as cheap as hand work, although from the mixing point of view they are satisfactory.

A very recent use of mastic has been in filling the joints of lug wood block pavements. The first work of this kind was done in Milwaukee in June, 1916, on the 16th St. viaduct. A pitch of 145° F. melting point was used, and a fine lake sand, heated to 400° F., was mixed with the pitch. A 50:50 mix was used throughout, and no difficulty was found in getting it into the joints. It is too soon to say how the filler will behave, but to date it is perfectly satisfactory from every point of view.

When a contractor takes his first job of bituminous mortar work he fails to realize the importance of having the sand as hot as the specifications require. The consequence is that he claims he cannot obtain 50 per cent of sand in the mix and make it work. It is absolutely essential that the sand be at least 250° F. when it is mixed with the pitch, and it is better if it is 350° F. If asphalt is the bitumen used, it will be better if the sand is 400° F. The higher melting point of asphalt requires a hotter mastic when it is applied.

METHOD AND COST OF APPLYING BITUMINOUS MORTAR FILLER TO GRANITE BLOCK PAVEMENT.

In connection with the improvement of Palisade Ave., Englewood, N. J., by the County Freeholders, one section, about 1,000 ft. in length, with a grade of a little over 8 per cent, was paved with granite blocks. The blocks were of the standard dimensions called for by the specifications of the American Society of Municipal Improvements. They were laid on a 1-in. sand cushion and in as close contact as possible, with joint not exceeding ½ in. The method of filling these joints with the bituminous mortar filler is described by Mr. Otto J. Swensson in the January Polytechnic, from which the following matter is taken:

The tar and sand were mixed and carried to the point of application in ordinary contractor's metal wheelbarrows. By securing a uniform quality of fine sand, thoroughly heating it before use, and mixing it in the barrel with the tar, as it was run from the kettle at a temperature of 290° it was possible, by vigorous stirring with a hoe, to incorporate the sand in equal volume with the tar. The mixture was immediately wheeled to the point of application and dumped on the surface of the blocks, where workmen with squeegees immediately brushed it thoroughly into the joints.

By requiring the men to work rapidly, it was possible, not only to fill the joints from top to bottom with the mixture (there having been previously placed in them, on account of the adoption of the ½-in. width, a small proportion of grit), but by care in the vigorous use of the squeegee, it was found that the amount of tar, which necessarily completely covered the surface, was not as thick nor as great in volume as that smeared over the surface of the blocks by two or three successive repourings. Investigation of completed work showed that in every case a thorough penetration of the filler had been effected down to the bottom of the block, and the large proportion of the sand had insured a consistency of the filler to avoid any running from the joints while leaving it with all required elasticity to furnish a foothold for horses. In order to avoid leaving the pavement with a sticky surface, a thin layer of sand was spread over it immediately after pouring. The completed work shows the efficacy of this method of joint filling.

There was required 1.7 gal. of bituminous material per square yard.

The approximate cost, including both labor and material, was:

	Per sq. yd.
Pitch	$0.143
Handling pitch	.02
Grit, 12 yd.	.011
Sand, 20 yd.	.019
Labor	.038
	$0.231

Cost of Maintaining Automobiles at San Diego, Cal.—The following costs on the maintenance of automobiles of the operating department of the city of San Diego, Cal., are taken from the November-December report of F. M. Lockwood, manager of the department:

	Mileage.	Average miles per gal. gas and distillate.	Average cost per mile.	Average cost per car.
November	15,952	13	0.038	$39.89
December	13,531	11	.027	27.01

These automobiles are repaired at the city's shops. A mixture of gasoline and distillate is used.

PUBLIC ROAD MILEAGE IN UNITED STATES.

In 1904 the U. S. Office of Public Roads adopted the policy of conducting at 5-year intervals an investigation to determine the mileage of improved and unimproved roads, the revenues for road purposes and other related data. The bulletin covering the investigations for 1914 was issued on Jan. 12 last. Table I from the bulletin shows the road mileage, revenue and other related data for the United States in 1914, 1909 and 1904.

TABLE I—ROAD MILEAGE, REVENUE, AND OTHER RELATED DATA FOR THE UNITED STATES, 1914, 1909, 1904.[1]

	1914.	1909.	1904.
Total road mileage	2,445,761	2,199,645	2,151,379
Surfaced mileage	257,291.54	190,476.32	153,530.4
Percentage surfaced	10.5	8.66	7.14
Total revenue	$240,263,784.46	(2)	$79,623,616.56
State and local road and bridge bonds outstanding Jan. 1, 1915	$344,763,082.32	(2)	(2)
Land area (square miles)	[3]2,973,830	[3]2,973,830	[4]2,974,099
Population	[3]91,641,197	[3]91,641,197	[4]75,715,857
Rural population	[3]49,348,883	[3]49,348,883	[4]45,197,390
Assessed valuation	[5]$69,093,003,851	[5]$69,093,003,851	[6]$35,114,924,911
Miles of road per square mile of area	0.82	0.74	0.72
Miles of road per 1,000 of rural population	49.5	44.6	47.6
Surfaced mileage per square mile of area	0.086	0.064	0.052
Surfaced mileage per 1,000 of rural population	5.21	3.86	3.39
Road and bridge revenue per mile of road	$98.22	(2)	$37.01
Road and bridge revenue per square mile of area	$80.79	(2)	$26.77
Road and bridge revenue per capita	$2.62	(2)	$1.05
Road and bridge revenue per $100 assessed value	$0.35	(2)	$0.23

[1] Exclusive of District of Columbia, Alaska and island possessions.
[2] No information obtained. [3] 1910. [4] 1900. [5] 1912. [6] 1902.
Miles of road surfaced between 1909 and 1914, 66,815.22.

Other results of the 1914 investigation follow:

The total revenue applied to roads and bridges in the United States in 1914 amounted to $240,263,784. This includes state appropriations, motor vehicle registration and license fees, amounts derived from local taxation, and expenditures from state and local bond issues. In 1904 the total revenue applied to this purpose amounted to $79,623,616, thus showing an increase for the 10-year period of $160,640,168, or 201.75 per cent.

The revenue available for road purposes increased from $37.01 per mile in 1904 to $98.22 per mile in 1914—an increase of 165 per cent, but the actual financial burden upon the taxpayers did not increase in the same ratio. This was due to the fact that property values increased during the same period to such an extent that whereas the average tax burden per $100 of assessed property value was 23 ct. in 1904, it had increased to only 35 ct. in 1914, an increase of 52 per cent, or less than one-third the rate of increase in the road fund.

The state and local road and bridge bonds outstanding Jan. 1, 1915, amounted to $344,763,082, comprising $115,324,500 of state bonds and $229,438,582 of local bonds. State bonds have been issued in California, Connecticut, Idaho, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, Utah, and Washington, and were authorized in New Mexico in 1912, but not sold until 1915. The constitutions of Kansas, South Dakota, and Wyoming prohibit these states from participating in works of internal improvement, and consequently, from issuing state bonds.

On Jan. 1, 1915, there was in the United States a total of 2,445,761 miles of road, of which 257,291.54 miles, or 10.52 per cent, were surfaced. This does not include the streets in incorporated cities and towns. By comparing these figures with those obtained in former investigations, it appears that between 1909 and 1914, 66,824 miles of road were surfaced.

Of the 257,291.54 miles of surfaced roads in the United States on Jan. 1, 1915, 116,058.12 miles, or 45.11 per cent, were gravel; 64,898.43 miles, or 28.22 per cent, were macadam; 44,154.73 miles, or 17.16 per cent, were sand clay; 10,499.79 miles, or 4.08 per cent, were bituminous macadam; 2,348.43 miles, or 0.91 per cent, were concrete; 1,593.88 miles, or 0.62 per cent, were brick, and 17,738.16 miles, or 6.90 per cent were surfaced with various materials.

A STEP TOWARD THE RATIONAL DESIGN OF CONCRETE PAVEMENTS.

Contributed by S. T. Morse, Consulting Engineer, Carlinville, Ill.

Cross Section.—The theory of design of the concrete pavement includes the determination of the most economical form and of the minimum thickness required to permanently resist the forces tending to rupture the slab. These forces result from changes in the temperature or moisture content of the concrete, or from superimposed loads, both concentrated and distributed, or may be caused by a shifting of the points of support of the slab, due to physical changes in the necessarily more or less unstable earth foundation. It is contrary to all experience and practice to assume that a foundation constructed from 6 to 8 in. below the surface can by any process be made perfectly stable and immovable. The effect of abrasion and wear, resulting from continued traffic, must be considered. Some features of the design may be varied with the nature of the subsoil, the location, and the character and amount of traffic.

Failures in concrete pavement slabs usually occur in the form of transverse, longitudinal, or diagonal cracks, and the causes of these will first be discussed in detail.

Transverse Cracks.—It is estimated that 20 per cent of the defects that appear in concrete pavements occur in the form of transverse cracks. The forces tending to crack a pavement slab transversely are:

First: Shrinkage of the concrete when curing without an abundant supply of water. This is probably the most frequent cause of transverse failure. The amount of shrinkage depends, mainly, on the richness of the concrete and on the amount of water supplied to the slab during the first weeks after construction. Judging from tests of Considere and others, the amount which the concrete may be expected to shrink in the first 30 days, under unfavorable moisture conditions, is approximately 0.05 per cent with a 1:2:4 mixture, and 0.10 per cent with a 1:1:2 mixture. In a block 50 ft. in length this is equivalent to a shrinkage of ¼ to ½ in., and is about as much as the contraction caused by a change of 100° in temperature.

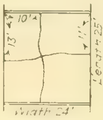


Fig. 1—Typical Lines of Rupture in Wide Slabs.

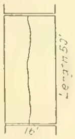


Fig. 2—Typical Lines of Rupture in Narrow Slabs.

Second: The contraction due to changes of temperature in the concrete. Contraction tends to slide the ends of the slab on the foundation toward the central transverse section, and when the resistance is great, tensile forces are generated which, it is believed, frequently rupture the slab transversely.

Third: Transverse cracks have, no doubt in many instances, been caused by concentrated loads passing over the center of pavements while periodically lacking central support. This is more likely to be the cause of rupture where the width of slab approximates the length than in cases where the length of slab greatly exceeds the width, see Fig. 1, because of the radial lines of force in a practically circular slab.

Longitudinal Cracks.—It is estimated that 60 per cent of the defects in concrete pavements are longitudinal cracks. These are irregular in outline, unsightly, and under traffic rapidly break down and widen. At least 80 per cent of the damage to the appearance and serviceability of concrete pavements result from longitudinal cracks. See Figs. 1 and 2. The forces tending to crack a monolithic pavement longitudinally are:

First: Freezing and thawing. The heaving action of frost in the ground at the sides of the pavement will cause a movement sufficient to raise the edges of the concrete, thereby lifting the entire slab or breaking it near the center. The writer has found this uplift at the sides to be, in extreme cases, as much as ¾ in. On thawing, a settlement occurs at the sides, producing a reversal of stress.

Second: Shrinking or swelling of the foundation earth. During dry weather, large cracks are frequently observed in the soil, due to a horizontal shrinkage. A fact equally well known is that earth, especially clay, swells on absorbing moisture. It is reasonable to assume that this shrinkage or swelling occurs in a vertical as well as in a horizontal direction. Such a swelling or shrinking produces a vertical movement sufficient to raise or lower the sides of the slab. While the earth is absorbing moisture, an upward pressure at the side is exerted which causes the slab to act as a simple beam; and when the earth again dries the sides are lowered first, which causes a cantilever action. Unless the slab is made of proper thickness a failure may be expected. Nearly all the cracks which have occurred in the pavements under the writer's notice have occurred in the months of May, June and July. An experiment, conducted by the writer, substantiates in a limited measure the above reasoning. A tile 14 in. in diameter and 18 in. in height was filled with well compacted earth, and on being saturated the surface rose 0.41 in. A weight of 150 lb. was then placed on the earth, when it settled continuously for seven months, a total amount of 0.55 in. The earth was then saturated and frozen, and the weight was lifted 0.16 in. An article published in Engineering and Contracting, Nov. 17, 1915, entitled, "Some Brick Paving Lessons Learned in Overcoming Faults in Original Designs," also refers to "This same peculiar earth movement."

Third: Settlement of an earth fill. The settlement of the sides of an earth fill may exceed that of the center, which is usually more compact, by 5 per cent. This causes a cantilever action in the slab. Even with a foundation on an old dirt road, the sides are less compact and dense than the center.

Therefore, a pavement of concrete may be cracked longitudinally by bending moments caused from upward pressure near the sides, or by the settlement of the ground beneath the sides, since the flexibility of a concrete slab is not sufficient to allow it to conform to these unequal movements in the foundation. The fact that many miles of concrete pavements are cracked longitudinally is ample proof that the section was not properly designed to resist the forces acting upon it.

Diagonal Cracks.—Diagonal cracks are of rather infrequent occurrence, except in pavements where the width of slab is more than 70 per cent of its length approaching a circular slab condition. In such cases they frequently occur, and are generally caused by concentrated loads passing over the center of the slab while periodically lacking central support.

The slab must be designed to sustain itself under the above mentioned conditions of support and the assumed traffic. Since it is the observation of the writer that a majority of cracks are caused by swelling or contracting of the foundation earth, due to its changing moisture content, especial attention will be paid to the stresses resulting from this phenomenon.

Thickness of Slab.—A pavement section is shown in Fig. 3, which illustrates the progressive saturation of the soil below the sides and extending toward the center, and shows the relative supporting forces thereby generated. It is apparent that the centroid of application of these supporting forces is at some unknown and shifting point between the center and edges of the slab, and is probably near the edge during wet or freezing periods, and near the center during dry periods. Also, since it has been shown by Mr. J. W. Pearl in Engineering and Contracting, Feb. 11, 1914, and by Mr. E. B. McCormick before the Eleventh Annual Convention of the American Concrete Institute, Chicago, Feb. 9, 1915, that a concentrated load on a concrete slab is distributed over a circular area which has as its diameter, approximately, the width of the slab, it is manifest that a solution of the problem of determining the stresses acting to crack the slab becomes difficult, and the results obtained constantly change as the points of support change. But conditions may be assumed that will produce the maximum and the minimum stresses, and corresponding solutions made which will indicate definitely the range of change. After the correct form of an equation has thus been determined an inspection of a large number of concrete pavements which have cracked longitudinally, and those which have not so cracked will enable one to supply the constants in the equation which will provide a safe thickness for any known width under practical conditions.

Maximum Stresses.—The conditions that produce the maximum stresses and require the maximum thickness of slab exist when the slab is loaded with a concentrated load at the center, and when it is supported along its longitudinal edges. The equation for thickness under these conditions will be determined.

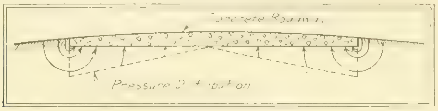


Fig. 3—Section of Roadway Showing Progressive Saturation Extending from Sides Toward Center by Action of Capillary Attraction.

The following nomenclature will be used:

Let M = bending moment.
M_c = resisting moment, due to tension in concrete.
M_s = resisting moment, due to tension in steel.
B = breadth of slab, or diameter of circular slab, in feet.
r = radius of circular slab $= \frac{B}{2}$.
d = depth of concrete in inches.
d^1 = depth of reinforced beam, assumed as 4-1".
d^2 = moment arm of steel $= 0.94d^1$ for small percentages.
b = breadth of beam, assumed as 12".
A = area of steel placed transversely in section 12" wide.
n = ratio of modulus of elasticity of concrete to steel.
f = tensile stress in pounds per square inch in extreme fibre of concrete, assumed at 200.
f^1 = stress in steel, assumed at 3,000 pounds at time of first crack.
w = dead load in pounds per square foot $= 12d$.
e max. = effective width, considered to be the width of slab, which, if subjected to a load, P, uniformly distributed along the center of section, will have the same maximum fibre stress as that showed under the concentrated load P, shown by experiment to equal 0.6B + 1.7, or approximately 0.75B.
P = concentrated load in pounds, assumed as 8,000.
P^1 = portion of concentrated load supported by a beam 12" in width $= \frac{P}{\text{e max.}} = \frac{P}{0.75B}$.

Then for a simple beam 12 in. in width,

$$M \quad \frac{12wB^2}{8} + \frac{12P'B}{4} = M \cdot = \frac{fbd^2}{6}$$

$$d = \frac{3wB^2 + 6P'B}{4f}$$

$$d^2 = \frac{9dB^2}{f} + \frac{3P'B}{2f}$$

It has been shown by the experiments recorded in Bulletin No. 28 of the Highway Department of the State of Ohio that the maximum effective width of a concrete slab, loaded with a concentrated load at the center and supported at each side is equal to 0.6B + 1.7, and for purposes of simplification, since within the usual limits of the width of pavements the error is small, e_{max} will be considered to equal 0.75B. (See, also, Engineering and Contracting May 17, 1916, page 449, Table 2, and context.) Therefore

$$P' = \frac{P}{0.75B'} \text{ and}$$

$$d^2 = \frac{9dB^2}{f} + \frac{2P}{f} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Equation (1) indicates that the stress produced by a concentrated load is independent of the span of the slab, when supported at its ends, and when its width is at least equal to 1.35B + 3.8, as demonstrated in Bulletin No. 28. The thicknesses of slab resulting from a use of Equation (1), allowing an extreme stress of 400 lb. per square inch of tension in the concrete (see recent tests at University of Illinois which show a modulus at rupture of 450 lb. in concrete slabs), are so great that in view of all experience it is manifest that this assumed extreme condition of support seldom exists in concrete pavements.

Minimum Stresses.—The conditions of support which, under a concentrated load at the center of the slab, produce the stresses that may reasonably be assumed to be the minimum stresses will exist when the slab is supported at all points by a uniformly yielding foundation. The concentrated load under these conditions is distributed by the slab over a circular area, having its outlines more or less regular, and having for its diameter, approximately, the width of slab. This method of load and stress distribution is verified by the experiments of Mr. E. B. McCormick, and in Bulletin No. 28, both as above mentioned. The complete demonstration, ascertaining the stresses in plain concrete slabs under these conditions, is given in Engineering and Contracting Feb. 11, 1914, and will not be repeated here. The final results therein obtained will be combined and condensed, so as to be readily applied to the concrete pavement problem.

Considering the slab as circular, and supported by a uniformly yielding foundation, the bending moment produced by the dead load is

$$M \quad \frac{2nrwr^2}{6},$$

and the bending moment produced by the concentrated load is

$$M = \frac{Pr}{4}.$$

Combining and equating to the resisting moment,

$$\frac{2nrwr}{6} + \frac{Pr}{4} \quad \frac{2nrfd^2}{6}$$

and

$$d^2 \quad \frac{wr}{f} + \frac{3P}{4nf}$$

Substituting the values of w and r, and cancelling n with 3,

$$d^2 = \frac{3dB^2}{f} + \frac{P}{4f} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Equation (2) also indicates that the stresses produced by a concentrated load under such conditions are independent of the span or diameter of the slab. The thicknesses of slab resulting from a use of Equation (2) are so small that, in view of practical experiences, it is manifest that this ideal condition of support does not at all times exist.

Example and Experience.—A summary of the results of experience which has come to the attention of the writer will now be considered.

The Seventh Annual Report of the Wayne County Road Commissioners submits a list of service records which represents the results obtained from an examination of 8,430 sections, 25 ft. in length. The curve platted in Fig. 4 has been prepared from these data. By a personal inspection of many of these pavements, the writer observed that the pavements which were 12 ft. in width and 7 in. in thickness were seldom cracked longitudinally, while those that were 15 ft. or more in width and 7 in. in thickness were very frequently cracked in this manner. Fig. 4 illustrates these facts very clearly.

A pavement at Greenville, Ill., is 16 ft. in width and 8 in. in thickness, and only 4 per cent of this pavement has cracked longitudinally. See circle 3, Fig. 4. Also, the Troy and Fairground roads at Edwardsville, Ill., are 15 ft. in width and 6 in. in thickness, and 23 per cent of the number of sections of both roads have cracked longitudinally (see circle 4, Fig. 4). The Carlinville road at Carlinville, Ill., is 16 ft. in width and 6½ in. in thickness, and 34 per cent of its sections have so cracked (see circle 5, Fig 4). High St. pavement at Carlinville was constructed with a centrally divided slab, making each slab 9½ ft. in width and 6½ in. in thickness, and only 1 per cent of its sections have so cracked (see circle 1, Fig. 4). And the Main St. extension, also at Carlinville, constructed in the same manner as High St., each slab having a width of 8½ ft. and a thickness of 4½ in., shows only 7 percent of its sections cracked longitudinally (see circle 2, Fig. 5).

Figure 4 is a diagram showing the relative thickness to width, and the corresponding number of cracks per mile of concrete pavement. From these data, and from much other data which indicates the same general result, it may be observed that a concrete pavement, to remain uncracked, must have a thickness equal to at least 4.5 per cent of its width, and, considering Equations (1) and (2), the writer suggests that if the constants in Equation (2) be increased by the amount of one-fourth the difference of the corresponding constants in Equations (1) and (2) an equation rational in form will result which will provide a safe thickness for concrete pavements under all ordinary conditions. The equation suggested as as follows:

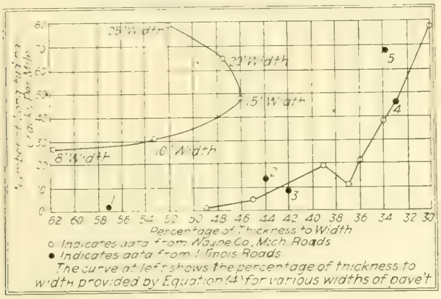


Fig. 4—Relative Thickness to Width and Corresponding Number of Cracks per Mile.

$$d^2 = \frac{4.5B^2d}{f} + \frac{P}{1.5f} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\text{or } d = \frac{2.25B^2}{f} + \sqrt{\frac{P}{1.5f} + \frac{5.06B^4}{f^2}} \quad (4)$$

Knowing the width of pavement, the assumed strength of the concrete, and the concentrated load, the equation is readily solved. The chief value of determining a rational formula for slab thickness is in its usefulness as a guide in designing pavements of different widths. The thicknesses so determined will at least be consistent with each other. It has, for some years, been the observation of the writer that narrow pavements are built too thick to be most economical, and that wide pavements are built too thin for safety.

Summary of Investigation for Thickness.—Formula (4) indicates that the minimum thickness should be not less that 5 in. Therefore at the edges, the pavement may be made 5 in. in thickness and be increased in thickness toward the center of the slab, as required by the formula. In order to show the comparative depths required in slabs of various widths, and concrete mixtures, and their comparative costs, Table I has been prepared. In comparison with current practice, Table I indicates that narrow pavements are usually given a greater thickness than safety and economy requires, and that wide pavements are usually given an insufficient thickness, and hence are likely to crack longitudinally. The comparison made in Table I between the probable costs of concrete pavements, when made of a 1-1-2 mixture, and when made of a 1-1½-3 mixture, indicates that in locations where an exceptionally high-class pavement is required it may be constructed with a 1-1-2 mixture at no greater cost per square yard than if a 1-1½-3 mixture is used, provided each class of pavement be made of a thickness which will provide equal strength. The amount of the herein assumed concentrated load is 8,000 lb., or about the load on one wheel of a 12-ton roller. In computing the cost columns, the assumed unit costs are: Cement, $1.25 per barrel; sand and stone, $1.25 per cubic yard; the labor of mixing and placing the concrete, $1.25 per cubic yard; and the cost of steel, 4 ct. per pound in place, which will, it is believed, cover the cost of transverse rods in the quantity specified, or will cover the cost of wire mesh or expanded metal having an equal percentage of transverse reinforcement, since it is more cheaply installed than rods. The cost of grading is not included.

TABLE I—RELATIVE COST AND THICKNESS OF CONCRETE SLABS.

Proportion.						Slab width, 10 ft.		Slab width, 15 ft.		Slab width, 20 ft.	
Cement.	Sand.	Stone.	Average modulus of rupture at age 60 days.	Assumed safe tensile stress f	Cost per sq. yd. of slab 1 in. thick.	Depth of slab, ins. d.	Cost per sq. yd.	Depth of slab, ins. d.	Cost per sq. yd.	Depth of slab, ins. d.	Cost per sq. yd.
					Plain concrete slabs.						
1	1	—2	450	240	$0.170	5.7	$0.97	7.2	$1.22	9.7	$1.65
1	—1½	—3	400	200	.148	6.4	.95	8.3	1.23	11.4	1.69
					Reinforced concrete slabs.						
1	—1½	—3	Steel	13,000	0.1%	6.15	1.00	7.9	1.29	10.8	1.76
1	—1½	—3	Steel	13,000	.2%	5.90	1.05	7.5	1.33	10.2	1.79

There is, as Table I shows, a greatly increased cost per square yard as the width of pavement is increased. Therefore in building a wide pavement, say over 12 ft., costs may be greatly reduced by the use of two or more adjoining slabs connected by a protected longitudinal joint. Bulletin No. 249, Office of Public Roads, U. S. Department of Agriculture, states as follows: "If the width of pavement exceeds 20 ft., longitudinal joints are also usually provided." This investigation indicates that it should be the practice to provide a longitudinal joint, dividing the slab, where widths are even much less than 20 ft., and that such a joint becomes a structural necessity for widths of pavement greater than 20 ft.

The underlying principle of the above discussion may be briefly stated by saying that the central thickness given to any concrete road should be made to depend, primarily, upon its width. The thickness given by any set rule or formula may properly be modified slightly according to the nature of the foundation, whether sand or clay. The constant factors used in any formula for thickness must be chosen from experience and good judgment, but must be such as will give due relative importance to both the distributed dead load and the concentrated moving load.

The prime value of a formula giving the central thickness for concrete pavements is that it enables the designer to design pavements consistently, according to the stresses, and thus avoid the construction of narrow pavements with more than the required thickness, or wide pavements with less. An example of such practice is found in present standards which make pavements 10 ft. in width 7 in. thick, and pavements 18 ft. in width 8 in. thick. As a matter of fact 7 in. is 1 in. more than is required in the first case, and 8 in. is 1 in. less than is required in the second case.

The End of the Road.—In a recent report Prof. B. K. Coghlan, of the Agricultural and Mechanical College of Texas, states that in one county where gravel roads extend but 8 miles from town, farmers living beyond the improved roads haul wood during dry weather to the ends of these roads and pile it there. When bad weather comes and it is impossible to work in the fields they haul this wood into town over the goods roads without difficulty and thus utilize a part of their time which would otherwise be largely wasted. One farmer uses two teams in hauling to the end of the improved road, where one team is unhitched and left with a friend and the other team used to drag the load into town.

"SKY-LINE" GRAPHS FOR PAVEMENT DATA.

The accompanying illustrations (Figs. 1, 2 and 3) show a method used by Prof. Geo. R. Chatburn of the University of Nebraska for graphically showing the relative costs of pavements. The data on which the charts are based were taken from the April 5, 1916, roads and streets statistical issue of Engineering and Contracting.

Figure 1 shows the range in cost and the relative amount laid (number of localities reported) at any particular cost. The area of the entire figure indicates the number of reports, and this may be taken as approximately proportional to the total amount of the particular type of pavement laid during 1915. By putting several types of pavement on one sheet the eye can take in at a glance the relative amounts, costs and range of costs of all the principal types of pavements laid in the United States during the year. It is an easy matter to estimate the centers of gravity of the several figures—that is, the average costs of the pavements.

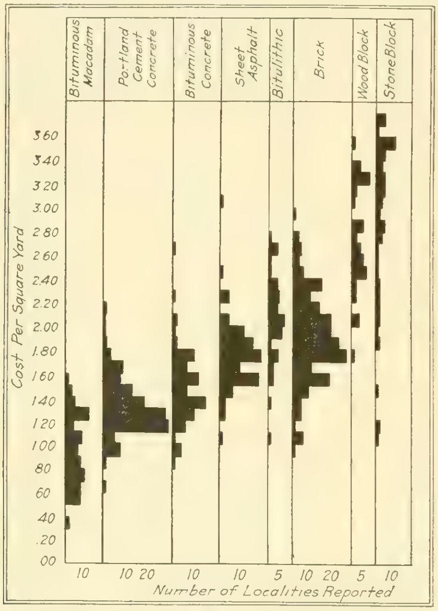


Fig. 1—Relative Amount and Cost of Pavement Construction in 1915.

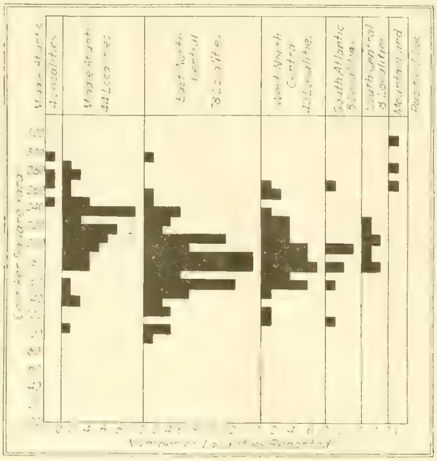


Fig. 2—Regional Influence on Cost of Brick Pavements.

Figure 2 shows the regional influence on the cost of brick pavement. The areas of the figures being proportional to the number of localities reported is at once an indication of the popularity of brick as a paving material in the several regious mentioned. The third chart was prepared to show the most commonly accepted term of guaranty and the effect, if any, a guaranty has on the cost of the pavement. The graph shows instantly that the 5-year period is the most popular and that the effect of a guaranty up to 5 years upon the cost of brick pavements is negligible.

This "sky-line" graph may be used in a variety of ways and is worthy of attention by those desiring to place data quickly and effectively before persons who have not the time or the inclination for more detailed study. These charts were made on the ordinary cross-section paper used by the students the blue lines of which failed to print.

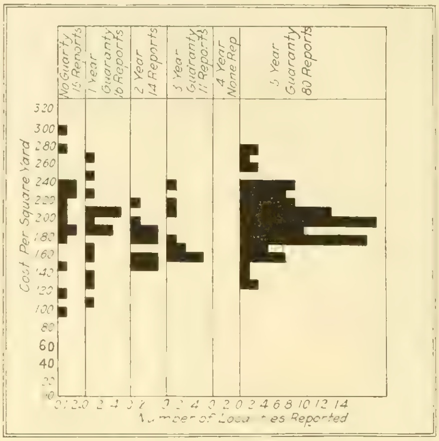


Fig. 3—Effect of Guaranty upon Cost of Brick Pavement.

A $1,000,000 ROAD IMPROVEMENT OF COOK COUNTY, ILLINOIS.

Cook County, Illinois, proposes the construction during the present year of some 60 miles of highway, involving an expenditure of about $1,000,000. The roads will have a paved width of 18 ft. Alternate bids will be received for pavement of Portland cement concrete of an average thickness of 7 in., asphaltic concrete of 2-in. thickness on 6-in. macadam base, and asphaltic concrete 2-in. thickness on 5-in. base of Portland cement concrete.

The contracts will cover sections ranging from 3 miles to 9 miles in length. Bids on the first section will be asked early in February, and every two weeks thereafter until all of the work has been let.

The engineering work for this improvement has been most skilfully handled. Not only have very complete plans and specifications been prepared, but an unusual amount of information has been compiled for the guidance of prospective bidders.

Two maps have been prepared to aid contractors in figuring on the work. One of these shows not only the location of the contemplated construction for 1917, and the roads now under construction and blocked, but it also shows the location and capacity of the railway sidetracks nearest the sections to be improved. The capacity of the siding is indicated by figures on the map. Boundaries of municipalities also are shown on this map.

The other map shows the location of sand, gravel and stone supplies in and adjacent to Cook County, and the name and address of the owners. These supply bases have been inspected by engineers and the material approved for the work.

Information of the kind shown in these two maps not only will save the contractor much time, but also will insure closer bidders.

The Cook County construction will be carried out under the direction of George A. Quinlan, Chicago, County Superintendent of Highways.

THE NEED FOR HIGHWAY ENGINEERING COURSES IN CIVIL ENGINEERING CURRICULA OF WESTERN COLLEGES.

Arguments for the adoption of highway engineering courses by Western colleges were presented by T. R. Agg, professor of Highway Engineering at Iowa State College, in a paper submitted at the recent meeting of the American Association for the Advancement of Science. In his paper, which is reprinted below practically in full, Prof. Agg points out the opportunities for engineers in the highway construction field.

The inquiries that come to the western colleges for engineers to fill positions in highway work show that a demand for such men already exists. These inquiries are received from state, county and municipal highway departments, from consulting engineers and from contractors. During the past two years the opportunities for employment in highway work have steadily increased in number and a survey of the field seems to indicate that the highway engineer can reasonably expect permanent employment in that field.

In the state of Iowa more than 200 highway engineers are employed by the various officials having jurisdiction over rural highways and several other western states employ as large a number. This number is, however, considerably in excess of that at present employed by most of the western states and is merely an indication of the number of highway engineers that will be required when the states give to highway improvement the necessary attention.

It is generally stated that the college graduate should first be placed in a subordinate position, there to undergo a period of seasoning under the guidance of an older and more experienced engineer before he is entrusted with authority or given responsibility. In recent years many college graduates who have obtained employment with highway departments have been put into responsible positions as inspectors or superintendents of construction within a few weeks of their graduation. This is not recommended, but is made necessary by the very rapid increase in the volume of highway construction. On this account employers are asking the college for men who have had some instruction relative to the special problems encountered in highway construction. Few of the western states are doing more than make a small beginning in the solution of their highway problems, and the volume of highway construction is certain to increase at a rapid rate, especially in the west where the mileage of public highways is so great. Along with that increase will come the more insistent demand for engineers for highway work.

Students in considerable numbers will register in highway engineering courses if such are offered. This is shown by the inquiries that are received from prospective students and from students who have registered in civil engineering, who wish to do major work in highway engineering. In the institutions with which the writer is familiar these do not constitute a large group, but the number is increasing each year. This points clearly to the fact that many students have weighed the matter and have concluded to fit themselves to enter the field of highway engineering. Students of this class are certain to become much more numerous in the near future particularly if the exceedingly rapid expansion in highway construction continues, with the consequent increase in the number of engineers employed. Already many students find summer employment in highway work and thus learn of the opportunities in that field and this leads some of them to direct their energies towards fitting themselves for that particular class of engineering work.

The colleges might not be justified in providing courses in highway engineering by the fact that men find ready employment in that field nor by the further fact that a certain percentage of students wish to enroll in such courses. The establishment in the colleges of courses in plumbing or brick laying might be justified on precisely the same grounds, but no one is likely to advocate such action.

Before a college is warranted in providing specialized courses it would seem that the proposed specialization should prepare the student for a field that affords adequate professional opportunity. Highway engineering, however, offers the possibility of high professional attainment.

The cities and towns of the western states are annually contracting for what is in the aggregate a very large mileage of pavement and the need for competent engineers in connection with that work is urgent. In the past this has not been a particularly inviting field for ambitious men on account of the uncertain tenure of office, the relatively poor pay, and the political nature of the administration. Conditions in these respects are steadily improving, and as the effects of a scientific management of public improvements become apparent, the movement to employ properly trained engineers will spread with increasing rapidity.

A large amount of the street improvement is being carried out in cities and towns that employ no permanent engineering corps and must, therefore, secure non-resident engineers for their work. Too often the character of the engineering indicates either ignorance or disregard of many of the recently established but generally accepted principles of highway design. Because of the poor construction, the loss of money and service to such cities is enormous and the continuation of such mistakes can be prevented only by employing engineers who are familiar with the principles of highway engineering and who are conversant with the best practice.

The casual observer sees many defects in the prevailing systems of rural highway administration and in the roadway surfaces constructed. The trained observer has become convinced that there exists a very pressing need for greater efficiency in handling the public funds appropriated for highway construction and for the exercise of greater care in the selection of types of roadway surfaces and in their construction. No concerted effort to encourage the employment of the technical expert in highway work can succeed until there has been established a reasonably stable supply of men of the requisite training.

The establishment of efficient administrative systems for municipal and for rural highway construction; the selection of suitable types of roadway surfaces; the design and construction of roads and pavements; the maintenance of costly improvements, all are technical problems of great complexity and their proper solution presents to the highway engineer a professional opportunity of high order.

The highway system of the nation is now recognized as an indispensable public utility, and as such it must be improved and maintained in a high state of efficiency. Who shall say that participation in that development does not offer a professional opportunity comparable with that of the sanitary engineer, the structural engineer or the mechanical engineer, each of whom may enjoy unquestioned professional standing?

The pecuniary reward that may be anticipated by the highway engineer compares favorably with that enjoyed by engineers in other fields. College graduates are usually able to secure positions in highway work at a beginning salary of $75 per month with expense allowances when away from headquarters. County engineers receive from $900 to $5,000 per year. State engineers from $2,500 to $10,000 per year. The tenure of office is already as certain as in many engineering fields, and conditions are sure to improve in this respect because the public is beginning to realize that constant change in the personnel of a public office is costly and that men should be retained as long as their services are satisfactory.

Courses in highway engineering may be introduced into most civil engineering curricula without displacing any subject more valuable as general training. The highway instruction that can profitably be given to undergraduate students will not require to exceed ten or twelve semester hours. If this is distributed through two or three semesters it can be accommodated readily.

If it may be conceded that a college is justified in a utilitarian attitude toward its functions, which is the spirit of many western colleges, there are strong reasons for taking cognizance of the need for highway engineering courses.

The inclusion of highway courses in civil engineering curricula will be the means of bringing the opportunities of the highway field to the attention of students and will give them an opportunity to become familiar with the rudiments of highway engineering practice before they seek employment. Some students thus interested will after graduation continue their studies along highway lines and enter a professional career of great service to the public, and of profit to themselves.

The faculties of western engineering schools have for several years been aware of the trend toward a greater recognition by the engineering profession of the field of highway engineering and the consequent tendency to urge upon educational institutions the establishment of courses intended as special preparation for highway work. This situation has been met in various ways, according to the convictions of the administrative authorities. Some have declared uncompromisingly against any specialization whatever, others have provided in the civil engineering curricula, a highway option or a few elective courses in highway engineering, and in a few instances faculties have gone to the extreme of establishing a four-year course in highway engineering.

The question of the advisability of permitting specialization may be debatable as an educational policy, but that principle has already been tacitly approved. Mechanical engineering courses and the professional practice of the mechanical engineer differ from electrical engineering courses and the professional practice of the electrical engineer less than sanitary engineering courses and the practice of the sanitary engineer differ from highway engineering courses and the practice of the highway engineer. But most of the well established educational institutions of the United States offer mechanical engineering and electrical engineering as separate courses, with appropriate degrees.

There is, therefore, some precedent for the establishment of highway engineering options or electric courses in civil engineering curricula, once it is apparent that such courses will serve an adequate educational purpose.

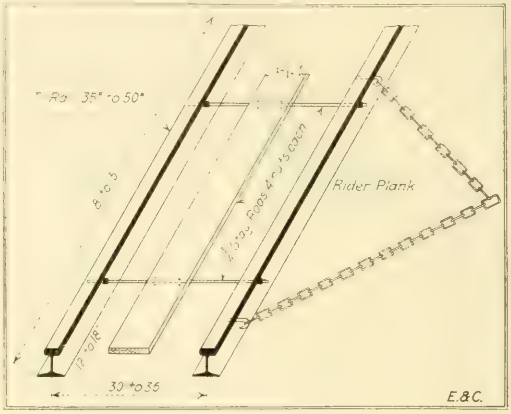
If it be conceded that an educational need is established by the fulfillment of the conditions outlined above, then there is a need for highway courses in the civil engineering curricula of western colleges. A demand for engineers to fill positions in highway work already exists and a survey of the field indicates that this demand will increase. The prediction may be entertained that under normal conditions the engineer may enter the field of highway engineering with the expectation of making it his life work. The compensation he may expect compares favorably with that in other lines of engineering. The professional opportunity is particularly attractive because of the magnitude of the problems involved and the possibility for great public service. The institution of highway courses imposes no insurmountable obstacles and need not impair the value of long established curricula.

Highway engineering courses will open the doors upon new opportunities for college graduates; will be in keeping with the progress of the engineering profession; will eventually insure better returns to the public for money expended for highway improvement and will, therefore, be a wise educational policy.

A systematic record of the construction, the wearing qualities, the upkeep and the length of life of roadways in the state of Washington was recently decided advisable by the joint meeting of the State Association of County Commissioners at Tacoma. As a consequence a system of records will be devised. This will give in detail all the facts of construction and maintenance. The tabulation will be kept in the office of the county engineer.

T-RAIL ROAD DRAG.

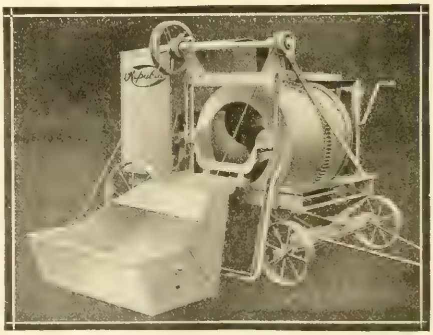
The accompanying illustration shows a road drag, designed by Chas. L. Wood, County Engineer of Lowndes County, Mississippi, and used with excellent results on clay-gravel roads. The drag is made of two pieces of castoff railroad rail, connected by two or three rods and furnished with a pull-chain. A rider plank may be attached if desired. Any crossroads blacksmith can build the drag to any dimensions desired. Mr. Wood finds that a machine made of two 40-lb. rails 15 ft. long dresses up the road in fine shape with one round, but for general work a length of 8 or 9 ft. will be more convenient. When one edge of the rail becomes dull the chain may be attached to the other, thus reversing the machine. The angle of the drag with the axis of the road (which determines the crown) is controlled, of course, by the "hitch," which may be at any point on the chain.



Sketch of T-Rail Road Drag.

A 1917 MODEL LIGHTWEIGHT MIXER.

A new model lightweight sack size concrete batch mixer having a number of labor saving devices and improvements is illustrated herewith. This is the 1917 model mixer manufactured by the Republic Iron Works, Tecumseh, Mich.



1917 Model Republic Mixer.

This mixer was designed to meet the requirements of both large and small contractors for a light, easily moved machine, which has sufficient capacity to handle a full bag of cement with all average mixtures, at the same time supplying a machine which is light in weight and easily transported and placed on the job.

THE RELATION OF THE ENGINEER TO THE ROAD CONTRACTOR.*

All contractors are in road construction work with the same interests in mind—that of financial returns for their efforts. There may be a few exceptions, as where, for sake of reputation or advertising purposes, some one will occasionally take the work. This is the exception and will not be considered. The success of your relations with the contractor will be largely determined by his mental attitude, and it has been my experience that a favorable atitude can best be secured only if he has promises of financial gain in his completed work. To obtain this condition it would be advisable to prepare, if possible, a fair estimate with the expectation that bids may be received below this figure, with the reasonable assurance that the successful bidder stands a good chance of making a fair profit.

The experience gained by the State Highway Department in their state aid lettings will give an idea of the effect of business conditions upon prices. In the lettings which took place in 1914, it was not at all unusual to find bids from reliable contractors that were 10 to 25 per cent and even a larger per cent below the estimates. It was true, however, that at that time the amount of such work was somewhat limited and such fierce competition resulted as to materially lower the level of construction prices.

In the season of 1916 just passed, we were confronted with an entirely opposite condition in which there was a scarcity of bidders and a corresponding increase in the costs. It was not at all infrequent to find several sections of roads that received no bids, while in others, even the most desirable from the standpoint of location and natural advantages, we received only two or three bids. Possibly the inexperienced had their curiosity satisfied by this time and no longer cared to continue in this work. From one extreme to the other, we were confronted with great care in determining, insofar as possible, the exact cost of materials required on these sections of roads. In addition, we were inclined to allow liberally in the matter of actual costs and make proper allowance for insurance, interest, bonds and depreciation.

It appears to me that in all branches of public work the level of prices should be so arranged that the contractor receives a reasonable and just compensation for his services. This one thing has been very difficult to do in road improvement work in the last few years. It seems that many persons in private life have a very much mistaken idea concerning the profits that are received by contractors. Perhaps they do not always have opportunity to examine the conditions or nature of the work involved and concern themselves primarily with the contract price. This idea is erroneous, for, as a matter of fact, no class of people have secured less for their efforts within the last two or three years than the highway contractor. In many instances they themselves were to blame, for unfortunate conditions in the business world compelled them to pay for their labor and materials in a rapidly increasing market. It would be my suggestion that it is the duty of each engineer connected with work of this kind to advise others, less well informed on this subject, and endeavor to obtain for the road contractor those profits to which he is justly entitled.

It is my desire to call to your attention the care that you should exercise in the wording of contracts for road improvement. Nothing is easier than to advertise and receive bids on work of this kind, but in no other place may your judgment be used to better advantage than in the proper selection of the contractor best fitted to do the work. It would not be desirable to award for a few dollars difference to some uncertain, inexperienced, or dishonest contractor, with the expectation that by rigid inspection and force of the engineer, satisfactory construction will be had. Frequently it is found that unreliable or reckless bidders submit unusually low bids. I am of the opinion that a low limit should be set on bidding or very careful investigation made before awarding the contract on a bid that is materially lower than that of the nearest competitor. I would be led to believe that if careful investigation is made, in many instances you would find this low bidder to be incompetent of making an intelligent estimate of the costs, or that through an error, he has submitted a wrong figure, or perhaps used the wrong basis of computation.

It, no doubt, will happen that many of you will experience difficulty in controlling the action of the committees when the low bidder is an undesirable party. They will confront you with the argument that if he is in a position to secure bond everything should be satisfactory. The writer has had the personal experience of several pieces of construction which, through unfortunate circumstances beyond the control of any one, were awarded to parties who later were unable to complete their contracts. The bond is useful in its way, protects the party of the second part and insures completion, but you will encounter the most exasperating circumstances and vexatious delays when you attempt to take over the work and endeavor to proceed to completion. Do not lose sight of the fact that time should be the essence of your contract. No one thing perhaps will cause you more bad feeling and loss of road improvement sentiment than delay in completion. The time to avert a large part of such grievances is on the day of awarding the contract.

In public work there is often the tendency for various political factions to exert their influence in an effort to secure the award for some political friend. It will be represented that their friend is good, honest, industrious, in fact possesses all essential qualifications for a successful contractor, and how much more satisfactory to local interests it would be to award it to him. It would appear advisable for you to insist that each bidder stand upon his own merits. If you think him deserving, do not hesitate to recommend him favorably to your committee. However, the most contemptible individuals with whom you will have dealings in an engineering way will be those operating under the impression that they are the favored son of some politician or committee. The contract is scarcely started before dissension arises; by the time it is half finished there has been at least one-half dozen investigations and reports; by completion, if that time ever comes, the work is usually in the hands of the bondsmen. After completion, sentiment is about equally divided condemning both the contractor and the engineer, and the public is disgusted with highway improvement.

The success or failure of road improvement may be largely due to the confidence that you, as highway engineer, are able to gain with the contractor. I very much prefer to have him feel that I have confidence in his honesty and in his ability to proceed satisfactorily. It would be well, however, to have him understand that you expect his co-operation and assistance in aiding the resident engineer to dispose of the many details which will, from time to time, come up. It should be maintained that your inspector or resident engineer has authority, and that you will expect the contractor to consult with him frequently. A word of caution may be added at this point and that is—do not became so lax as to permit the contractor to feel that he is in a position to make whatever changes or suggestions that he desires. You should have will power and ideas of your own and combat his suggestions when the occasion offers in an agreeable and diplomatic manner. To sum it up, think for yourself and have done what should be done, but make him feel that it was his suggestion and industry that produced the results.

It seems worthy to note here that you will be frequently called upon to settle questions arising over terms of contract, and it would be well if you considered previously your duties on this point. In almost all specifications today you will find a clause which reads somewhat as follows:

> It is agreed by both the parties of this contract that the engineer shall act as referee in all questions arising under the terms of this contract between the parties thereto and that the decision of the engineer in such cases shall be final and binding on both alike.

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*Abstract of an address delivered on Jan. 17 by A. H. Hunter, Division Engineer, Illinois State Highway Department, in the short course in highway engineering at the University of Illinois.

I feel that many of us are inclined to forget this relation of the contractor when decisions are to be made and in place of judging fairly and squarely are inclined to favor to a great extent the party of the second part. Just remember that you are the referee and make your decisions accordingly.

The conditions encountered in road improvement construction have been materially changing within the last few years. The original contractors were those who had received their education in the school of experience and they were inclined to be distrustful of the engineers with their "new fangled" methods, as they called them. It is found today that most of the successful contractors are men who have enjoyed the advantages of an early education, and supplemented this with such experience as time allowed. Thus it is found that the engineer and contractor are more nearly approaching each other from the standpoint of training. This enables them to discuss on an equal basis subjects relating both to the contractor and the engineer. It is this similarity of understanding, appreciation of the other's position and expression of feeling and sympathy which will eventually result in more amicable relations in the future road building in this state.

COST OF BITUMINOUS SURFACE ON CONCRETE ROAD.

A defective concrete road in Deerfield Township, Lake County, Ill., was given a bituminous surface at a cost of 18.5 ct. per square yard. The road was built in 1912 under very poor conditions and very late in the season. The method and cost of applying the bituminous surface are given by B. H. Piepmeier, Maintenance Engineer, Illinois State Highway Department, in the January Illinois Highways:

The tar surface was applied as follows: The entire pavement was first thoroughly cleaned with a rotary broom. The surface was then treated with Tarvia B at the rate of ¼ gal. per square yard, applied under pressure from the Barrett truck, which delivered the material direct from the Chicago plant.

The Tarvia B was applied first to act as a primer and to absorb any surplus dust and to penetrate and waterproof the porous spots. Tarvia X at 225° F. was then used to fill all cracks and large depressions. In connection with the Tarvia X the necessary sand, chips and stone were used to bring the surface to a true cross section. Tarvia A at the rate of about ½ gal. per square yard was then applied under pressure from the oil truck at a temperature of about 200° F.

Immediately following the application of Tarvia A the necessary torpedo gravel (size ⅛ in. to ¼ in.) was spread over the surface to hold the bituminous material, prevent it from sticking and to insure a more uniform wearing surface.

The resulting pavement presents an appearance a great deal like bituminous concrete road. It is not expected that surfaces of this kind will be permanent, yet if the necessary precautions are taken in cleaning the pavement and applying the bituminous material very satisfactory results may be expected.

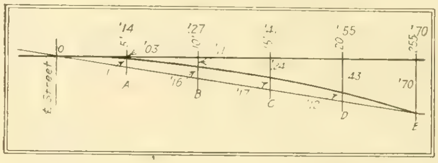
It is probable that such a surface occasionally will need a very light application of tar covered with torpedo gravel. Mr. Piepmeier states that such treatments if carefully constructed and maintained will restore faulty sections of concrete pavements to a very serviceable condition at a very reasonable cost. The following shows the total cost and cost per square yard of the work:

Total square yards in defective pavement	6,000	
Total square yards new pavement treated with Tarvia B	1,000	
Total amount of Tarvia B used, 1,495 gal., or 0.21 gal. per sq. yd.		
Total amount of Tarvia A used, 3,009 gal., or 0.50 gal. per sq. yd.		
Total amount of Tarvia X used, 1,510 gal., or 0.25 gal. per sq. yd.		
Tarvia A, B and X, 6,014 gal. at average price of 11½ ct. per gal. delivered	$ 692.83, or	$0.115 per sq. yd.
Torpedo gravel and stone, 172 cu. yd. at $1.85	318.07, or	0.053 per sq. yd.
Labor	100.00, or	0.017 per sq. yd.
Total	$1,110.90, or	$0.185 per sq. yd.

METHOD OF SETTING GRADE STAKES FOR STREET PAVING WHERE THE GUTTERS ARE OF DIFFERENT ELEVATIONS.

The following method of setting grade stakes when the gutters are of different elevations was developed by Wayne Blackford, Shelbina, Mo., while engaged in such work recently. The accompanying illustration shows the cross section of parabola on a 51-ft. street. The procedure is as follows: First, set center stake at O, the crown above the average of the curbs. Second, stretch string between O and X, the toe of the gutter. Third, set stakes A. B. C, etc., by measuring above string.

By this method it is possible to make the finished surface a true parabola (or any other form desired), no matter if the difference between gutters is more than the crown of the paving. The street will look well and there will always be a high place at some point to divide the water between the gutters. This method takes the place of the rule of thumb way of throwing the crown off center on such streets. The crown is shifted to where it should be theoretically, depending on the amount of difference between the gutters.



Cross Section of Parabola on 51-Ft. Street.

All the data necessary for a certain width of street and a certain crown is worked out on a 3x6-in. sheet that will fit a loose leaf or field note book, making it convenient to carry into the field. All the instructions and measurements necessary for its use are given on it.

Each row of stakes across the street may be set by this method; or a better way, if the toes of the gutters are uneven, is to set a row at each property line or break in grade and "shoot in" the stakes between with a transit.

BELT FINISHING OF CONCRETE ROADS.

A recent innovation in concrete road construction is the use of a belt for finishing the surface. A description of the method employed on a Michigan road was given in the Nov. 1, 1916, issue of Engineering and Contracting. In the December Illinois Highways, Mr. H. B. Bushnell, Division Engineer Illinois Highway Department, relates his experience with this method. The first experiments were made by the Illinois Hydraulic Stone & Construction Co. of Elgin, Ill. Two belts were secured: a 3-ply 8-in. canvas belt and a 1-ply 10-in. belt, both having a composition rubber covering.

The concrete was mixed at such consistency that when deposited in a pile it would tend to flatten, but would not run at the edges. The concrete was struck off in the usual manner and after the surplus water disappeared from the surface of the concrete the 8-in. belt was dragged back and forth over the pavement with practically the same motion as used for the strike board.

Just prior to the concrete taking its initial set the pavement is gone over a second time with the belt. This second floating grinds down all the ridges left after the first floating.

The second floating leaves a gritty, granular mortar surface entirely free from ridges, flat spots, or pockets. It was found that better results could be secured by the use of a 10-in. belt for the second floating because of its greater weight, but if the heavier belt was used for the first floating it had a tendency to flatten the crown in the soft concrete and to dig into the surface.

During the past few weeks eight other contractors on state aid work in northeastern Illinois have commenced to use these belts. Some of them have purchased new canvas belts and have had considerable difficulty, due to the stiffness of the material. This defect can readily be remedied by shipping the belt enough to limber it up. The plain canvas belt pulls harder than when covered with rubber, but not to such an extent as to be objectionable.

In Kane County a contractor placed from 600 to 800 sq. yd. of 18-ft. concrete pavement per day and had no finisher on the pay roll. The strikeboard men handled the belt and did the edging. Where armored joints are used it is necessary to do a small amount of hand floating around the joint, but this is done by the men who place the joints.

MAINTENANCE COST OF A BITUMINOUS MACADAM ROAD.

The Federal Aid Post Road in the state of Maine was completed on Dec. 1, 1915. It is 20.87 miles in length with a bituminous macadam surface 16 ft. wide and 2½-ft. earth shoulders. The surfacing is 6 in. thick and is constructed of native stone and asphaltic oil applied by the penetration method. The cost of maintaining the highway from Dec. 1, 1915, to Oct. 1, 1916, averaged $90.67 per mile. The maintenance costs in more detail are given by Mr. Irwin W. Barbour, assistant engineer, in an article in the December Cornell Civil Engineer. They are as follows:

Towns.	Miles.	Inspection.	Cutting bushes.	Dragging.	Ditches and culverts.	End walls and culverts.	"V" drain and St. base.	Guard rails.	Patching surface.	Surface treatment.	Total.
Falmouth	4.05	$ 45.80		$ 80.19	$ 39.98	$ 1.27	$51.04	$0.31	$209.39	$ 92.94	$ 520.92
Cumberland	3.16	32.78		22.69	30.59	.60	13.95		99.97		200.58
Yarmouth	3.12	37.39	$ 2.88	28.45	80.93	4.46			177.13		321.24
Freeport	7.56	24.88	6.52	89.65	95.83	3.97		1.27	247.96	9.92	482.00
Brunswick	2.98	44.45	8.00	63.00	37.51	2.17		.64	107.53	94.21	357.51
Totals	20.87	$185.30	$17.40	$283.98	$284.84	$12.47	$64.99	$2.22	$841.98	$197.07	$1,882.25

Average per mile, $90.07.

REMOVING ASPHALT PAVEMENT WITH HAMMER DRILLS.

Hand air-hammer drills were used by P. J. Moran, a contractor of Salt Lake City, Utah, for removing a strip of asphalt and concrete pavement alongside the tracks of a street railway so that the rails might be shimmed and new pavement laid. A description of the job is given in the December Mine and Quarry, from which the following notes are taken:

In order to reduce time and labor in this work, Mr. Moran purchased two Sullivan DC-19, 40-lb. hammer drills, operated by a small steam-driven air compressor.

A line was laid out a foot from the outside of the rails and the drills were equipped with a special channeling bit to cut off the asphalt. When a sufficient distance had been channeled a gadding bit was used and the surfacing material was removed, exposing the concrete. The gadding bit was again used in breaking up the concrete. This was done by holding the drill in a nearly vertical position for wedging off pieces of the concrete. In this manner pieces from 4 to 8 in. square were broken off.

One man with the Sullivan drill was able to take up the asphalt and concrete at an average rate of 6 lin. ft. in 15 minutes; while the three men, "double-jacking," by the old method of hand work, required an average of 40 minutes to remove a like amount; that is, hand work required two hours to accomplish the same results secured in 15 minutes with the machines.

The following comparison, based on the job described above, may be interesting:

MACHINE WORK COSTS.
(Based on costs and prices in June, 1914.)
Cost of Plant.

1 Sullivan WK-3 portable compressor with 20-h.p. [illegible]	$1,780.00
2 DC-19 hammer drills	170.00
Hose, steel, etc.	50.00
Total	$2,000.00
Interest on plant at 6 per cent	$120.00
Depreciation, 15 per cent	300.00
Total	$420.00
Operating, 175 days per year, per day	$ 2.40
Engineer, per day	3.50
2 drill operators at $2.50	5.00
Gasoline, 20 gal. at 23 ct.	4.60
Oil, waste, etc.	.50
Total	$16.00
Progress per day, 8 hours	384 ft.
Cost per foot of work	$0.0416

HAND WORK COSTS.

6 laborers at $2.25	$13.50
Progress per day, 8 hours	144 ft.
Cost per foot of work	$0.0937
Saving on machine over hand work, per foot	.0521

WINTER MAINTENANCE OF EARTH ROADS.

Winter dragging of earth roads is advocated in "Illinois Highways" by Frank T. Sheets, Assistant Maintenance Engineer Illinois Highway Department, as a means for keeping earth roads in good condition. His suggestions follow:

The first way to care for an earth road in winter is to prepare it for this case by intelligent work in the summer, paradoxical though the statement may seem. No one should expect or permit an earth road to enter the winter period in a flat, undrained condition. The road should be well crowned, adequate side ditches should be provided, underdrainage should be placed wherever necessary. To be brief, the earth road should be constructed in summer.

In winter it is essential that the ditches, drains and culverts be watched and all obstructions to drainage removed. A few minutes' use of a shovel may eliminate a saturated roadbed, or a stopped up culvert.

Keep the ditches and culverts clean. Then when rain falls or snow and ice melts, far less damage will result. When drainage has been maintained, the problem of surfact maintenance presents itself. It is unavoidable that the surface should cut up under traffic during a thaw or during a rainy spell. Yet no one can say it is necessary to let this surface freeze in such a condition. Nothing more unpleasant can be experienced than traveling over a rough, rutted and frozen surface.

The road drag comes to the rescue of the earth road in winter with the same efficiency as in summer. If a rough, cut up road is dragged before a freeze and then frozen in the smooth condition, a boulevard is enjoyed until the next thaw. If a wet surface is dragged and then dried, a good road is also enjoyed.

It is not necessary to say how the dragging shall be done; the important thing is to get some one to use the drag. Common sense will soon teach how to perform the work. A study of weather predictions and a corresponding use of the drag at opportune times will work wonders with Illinois earth roads.

COST OF ENGINEERING ON HIGHWAY WORK.

The cost of engineering by the Maine State Highway Department for 23 gravel road contracts let in 1914 was 6.10 per cent, according to an article by Irwin W. Barbour, assistant engineer, in the December Cornell Civil Engineer. This percentage does not include office administration. Itemized the percentage is:

	Per cent.
Surveys	1.02
Plans and computations	[illegible]
Advertising	.91
Engineering during construction	4.11

The roads were located in 16 towns and aggregated 80.11 miles. The total cost was $525,383, the percentages for the various class of work being:

	Per cent.
Grading	33.77
Drainage	10.87
Surfacing	[illegible]
Culverts	8.43
Guard rails	1.55

Mr. Barbour gives the following figures on bituminous macadam, concrete, waterbound macadam and sand-clay roads constructed in 1914 and 1915:

	Bituminous macadam, 20.87 miles. Per cent.	Concrete, 5.47 miles. Per cent.	Waterbound macadam, 2.68 miles. Per cent.	Sand clay, 3.77 miles Per cent.
Engineering and inspection:				
Surveys	0.35	0.11	0.52	1.19
Plans and computations	.45	.26	.30	1.04
Advertising	.05	.02	.05	37
Engineering and inspection	3.73	2.91	4.70	3.83
Total engineering and inspection	4.58	3.30	5.57	6.43
Labor and materials:				
Grading	14.98	8.72	17.05	24.59
Drainage	13.83	7.21	16.94	11.92
Surfacing	61.66	76.51	54.09	46.55
Culverts	4.12	3.43	5.83	9.35
Guard rail	.82	.83	.52	1.16

FEDERAL ROAD FUNDS APPORTIONMENT.

The Federal appropriation for the fiscal year ending June 30, 1918, of $10,000,000 to aid the States in the construction of rural post roads has now been apportioned among the several States by the Secretary of Agriculture in accordance with the terms of the Federal Aid Road Act. Before making the apportionment, the Secretary, in accordance with the provisions of the act, deducted 3 per cent of the appropriation, or $300,000, to meet the cost of administering the act. The remaining $9,700,000 has been divided among the States as the act prescribes—one-third in the ratio of area, one-third in the ratio of population, and one-third in the ratio of mileage of rural delivery routes and star routes. Apportioned on this basis the money is divided as follows:

State.	Sum apportioned.	State.	Sum apportioned
Alabama	$ 208,297	Nevada	$ 128,796
Arizona	137,027	New Hampshire	41,993
Arkansas	165,378	New Jersey	118,425
California	302,127	New Mexico	157,475
Colorado	167,380	New York	501,440
Connecticut	62,180	North Carolina	228,763
Delaware	16,368	North Dakota	152,286
Florida	111,952	Ohio	373,810
Georgia	268,658	Oklahoma	230,278
Idaho	120,927	Oregon	157,374
Illinois	441,852	Pennsylvania	461,288
Indiana	271,495	Rhode Island	23,331
Iowa	292,351	South Carolina	143,615
Kansas	286,414	South Dakota	161,892
Kentucky	194,943	Tennessee	228,306
Louisiana	134,949	Texas	583,855
Maine	96,903	Utah	113,900
Maryland	88,094	Vermont	45,688
Massachusetts	147,701	Virginia	199,321
Michigan	291,567	Washington	143,768
Minnesota	284,788	West Virginia	106,540
Mississippi	177,811	Wisconsin	256,722
Missouri	339,440	Wyoming	122,393
Montana	196,574		
Nebraska	213,541	Total	$9,700,000

This is the second apportionment to be made under this act. For the fiscal year ending June 30, 1917, the appropriation was $5,000,000. For succeeding years, the appropriation is as follows:

1919	$15,000,000
1920	20,000,000
1921	25,000,000

These sums do not include the $1,000,000 which is appropriated each year for 10 years for the development of roads and trails within or partly within the national forests.

NEWS LETTERS.

St. Louis Items.

J. [illegible] Carroll, 413 W. Main St., Galesburg, Ill., reports his team outfit idle at that point.

Lane Bros. are wintering their outfit at Galesburg, Ill., and are in the market for any kind of team work.

Ed Harris returned from Mexico last week. He left here for Neoba, Ill., where he is going to build a lot of gravel roads in the spring.

P. J. Hannan Co. sublet the team work on their big Wabash job in western Missouri to Mell Peters. The Hannon Co. have several steam shovels on the way to this work and will begin operations as soon as they land on the job.

What is said to be the highest smokestack in Illinois has just been completed by the Niederholt Construction Co. of St. Louis for the St. Louis Smelting & Refining Co. at Collinsville, Ill. It is 375 ft. high, has a diameter of 44 ft at the base and tapers to about 17 ft. at the top.

Plans for eliminating River des Peres by an underground passage north of the southern boundary of Forest Park and straightening its channel between concrete banks south of the park at a cost estimated at $6,650,000 were approved yesterday by the Board of Public Service. A foul-water sewer already has been constructed along River des Peres from Manchester Ave. to its confluence with the Mississippi, and only the storm water is carried in its channel. The plans approved yesterday are expected to prevent any future overflow, such as that which cost eleven lives in 1915 and damaged houses throughout the course of the stream. A bond issue will be required to provide the necessary funds for the improvement and the board does not recommend that the work be undertaken until the price of materials recedes to normal. The plans were perfected by Wesley W. Horner, a civil engineer in the street department.

The highway deck of the new free bridge was thrown open to the public on Jan. 20. It was authorized in June, 1906, when the public voted a bond issue of $3,500,000 for the construction of a railroad and highway bridge to complete the contract. Contract for the piers was let July 29, 1909, and work commenced Dec. 20, 1909. An extra bond issue, $2,750,000, was voted Nov. 6, 1914. The cost of the finished bridge is approximately $6,000,000. The highway deck is 9,798 ft. long, was opened Jan. 20, 1917, and the railroad deck, 18,258 ft. long, will be opened Aug. 1.

That the highway bridge across the Missouri River at St. Charles, Mo., which was destroyed by fire last September will be in operation and cars running over it by Sept. 1, is information received by members of a committee of the St. Charles Chamber of Commerce when they called on W. S. Delahunt, secretary of the St. Louis & St. Charles Bridge Co., in the Commonwealth Trust Bldg. here last week. Enough capital to rebuild the structure has been secured. The company is awaiting a report on the steel parts that are being tested by the engineering department of the University of Illinois.

A. B. KOENIG.

PERSONALS.

Malcolm Patlin has been appointed county engineer of Leavenworth, Kan.

F. D. Pearse has been appointed county engineer of Franklin County, Iowa, succeeding A. G. Baker.

J. W. Mercer has resigned as county engineer of Lucas County, Iowa, to become county engineer of Ringgold County, Iowa.

O. W. Head, for the past four years division engineer for the Connecticut State Highway Department, has resigned to become secretary of the Robert Daly Co., New Haven, Conn.

The following officers were elected at the 32nd annual meeting of the Illinois Society of Engineers, held Jan. 25 and 26, at Chicago: President, W. D. Gerber; vice-president, J. G. Melluish; new trustees, Robert I. Randolph and F. W. De Wolf.

Fred Bennett, for more than four years highway engineer of Bexar County, Texas, resigned his office January 25, to become effective not later than February 10, to become one of the members of the firm of Julian C. Field & Co., consulting engineers, Denison, Tex. Mr. Bennett was associated with Julian C. Feild during 1910-11 during the building of the Denison road system, after which he went to San Antonio to become highway engineer for Bexar County. During his incumbency in that position he built the Bexar County highway system at a cost of slightly over $1,500,000, and since the completion of the road system has inaugurated an effective maintenance system for the county roads.

INDUSTRIAL NOTES.

R. H. Wilson, who has been in charge of the steel piling department of the Walter A. Zelnicker Supply Co. in St. Louis, is temporarily representing this company at 910 Hennen Bldg., New Orleans.

Mr. W. J. Berew, Secretary of the Pulsometer Steam Pump Co., Irvington, N. J., reports the largest demand for their pumps experienced by the company during the past 40 years. Their business during the month of January exceeded that of any other month in the history of the company by many thousands of dollars.

The Berger Manufacturing Co., Canton, O., announces the following appointments: R. W. Van Horn has been placed at the head of the building material products division. Norman A. Hill has been appointed efficiency engineer, with headquarters in the home office of the Berger Manufacturing Co. P. V. Stonerod has been placed at the head of the sidewalk light department and will be located in Canton, O. A. H. Bromley, Jr., contracting engineer, has been appointed chief engineer of sales department and hereafter will be located in the Canton office.

The Westinghouse Electric & Mfg. Co. will utilize a plot of ground recently purchased at Essington, near Philadelphia, for a new industrial center. The site embraces about 500 acres, with a frontage of approximately one mile on the Delaware River. Additional transportation facilities will be afforded by tracks from the Pennsylvania and Philadelphia & Reading railroads. This new center will be devoted to the production of large apparatus, the first group of buildings being for power machinery, principally steam turbines, condensers and reduction gears. The initial development will cost in the neighborhood of $5,000,000 or $6,000.000, occupying about one-fifth of the area of the entire plot. The group will consist of the following buildings: Two large machine shops, an erecting shop for heavy machinery, forge shop, pattern and pattern-storage shop and power house. Work will begin on these as soon as satisfactory building contracts can be let. The number of employes to be engaged at the new plant has not as yet been definitley determined, but will number several thousand people, and undoubtedly will be in the future equal the number employed at East Pittsburgh, representing over 20,000 people.

The second annual convention of the Trussed Concrete Steel Co. was held at Youngstown, O., Jan. 23 to 25 inclusive. Branch managers and representatives from every section of the country were in attendance—nearly 200 men taking part in the meetings. The convention was opened Tuesday morning by S. M. Fechheimer, general chairman and publicity manager. The principal address of the morning was by Julius Kahn, president, who reviewed the excellent work of the company for the past year and outlined a program for 1917 business. T. H. Kane, works manager, followed with an address on the progress made in the shops. The Tuesday afternoon session was devoted to the subject of contracts and credits and brought out two very valuable papers, one by O. W. Chaffee, Manager of the credit department, and the other by O. W. Irwin. These papers were followed by an interesting discussion. The Wednesday morning session was devoted to the subject of "Kahn Pressed Steel and Kahn Steel Buildings," with papers by C. I. Auten, department manager, and H. W. Faraday, followed in the afternoon by an address and discussion on "Reinforced Concrete" by R. D. Snodgrass, chief engineer. On Thursday morning P. M. Louwerse, manager of the sash department, gave a very valuable paper on the subject of "Steel Sash," followed by another by F. W. Cummer, and an interesting discussion. At the afternoon session Louis Baum, manager of the Kansas City office, presented a most interesting paper on "Floretyle Construction." The greater part of the Friday sessions were devoted to the subject of "Hy-Rib, Metal Lath and Highway Products." Mr. John Bowditch, manager of this department, presented the principal paper, followed by W. A. McIntyre, assistant manager. At the afternoon session interesting papers were presented by R. H. Page of the foreign trade department, and C. H. Gagen of the Chicago office. Gustave Kahn, manager of the sales department, outlined in a most impressive way the program for the work of 1917.

Waterworks and Hydraulic Issue
of
Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

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ARE THE ENGINEERING "PROBLEMS IN A CUBIC FOOT OF SOIL MORE DIFFICULT THAN THOSE IN BUILDING THE PANAMA CANAL"?

Engineers accustomed to designing and handling great masses of materials are apt to forget that there is such a thing as engineering with a microscope. Hence it will startle most of us to read that—

> It is no exaggeration to say that a cubic foot of ordinary garden soil presents more unsolved problems in biology than the entire solved problems up to the present time, and these problems are more difficult than the building of the Panama Canal, including both its engineering and biological achievements—more difficult than wireless telegraphy, than submarine or aerial navigation, for these latter have in part been solved.

This is the opinion of M. B. Waite in a paper on "Research and Agricultural Production," published last year in the Annals of the American Academy of Political and Social Science.

Mr. Waite briefly reviews the progress of knowledge respecting micro-organisms from the days of Ehrenberg (1830) when bacteria were first discovered, down to Koch's discovery of the germ of tuberculosis (1884). For more than 30 years bacteria were supposed to be the effect of fermentation, but in 1862 Pasteur proved that bacteria were the cause and not the effect. In 1870 he discovered the first bacterial disease, one that destroyed silk worms, and from that moment the grand march of the cohorts of science against disease began. Eight years later Burrill discovered that pear blight was caused by bacteria, the first plant disease to be proved to be caused by mocro-organisms.

Knowing the general character of the cause of most plant diseases, it later became evident that diseases could probably be overcome by the application of poisonous solutions to the plants. But it was not till 1883 that Millardet discovered that "Bordeaux mixture" would destroy vine mildew. So that scarcely more than 30 years have elapsed since we have had that vastly important word, "fungicide," to add to our dictionaries.

One botanist has estimated that the annual monetary losses from the corn and cereal smuts in America exceed all the taxes that go to our state and national treasuries! Yet most of these losses are preventable at very small cost, the method being to disinfect the seed before planting it. Sprinkling with formaldehyde water will destroy most smut fungi, and the same treatment is the remedy for potato scab and some other potato diseases. Chemicals will not kill certain smuts, but then other treatments are available. In the case of the loose smut of wheat, for example, the remedy is dipping the seed for 30 mins. in water at 130° F.—a temperature that kills the smut but does not kill the seed. The brown rot of peaches long resisted the known methods of killing other fungus parasites, but the problem was completely solved by the discovery that sel-boiled lime-sulphur, sprayed on the peaches, kills the fungi without injury to the peach.

Not all germs are foes of plants. Without certain germs the leguminous plants—clover, alfalfa, etc.—can not live. These leguminous plants have the power of assimilating nitrogen and thus actually aid in fertilizing the soil. It was discovered that this remarkable characteristic of the leguminous plants is due to the presence of a tiny bacillus that inhabits the roots of the plants and has the mysterious power of extracting nitrogen from the air. So now it is the practice to inoculate soils with these germs when alfalfa is planted, for otherwise the crop will not grow at all.

To every civil engineer a biological review of this sort is fascinating, for he sees in such history the application of science to the problems of economic production, which, in the final analysis, is all that engineering is. The civil engineers see, moreover, that before science can be applied it must be learned, and that before it can be learned its facts must be discovered. Therefore no class of men should be more keen and active in aid of appropriations for scientific research work than engineers. All of us are "keen for it." But how many of us are actively "plugging for it"? Comparatively few, we fear. Here, then, is one of the many useful lines of activity that engineering societies may well foster.

LET THE FEDERAL GOVERNMENT HELP THEM THAT HELP THEMSELVES, AND THUS ELIMINATE THE "PORK BARREL."

In a letter from Mr. George B. Hills, published in this issue, there will be found a very interesting fact and a still more interesting suggestion. Mr. Hills states that 18 counties in Florida, embracing about a third of the entire state, are about to organize a public corporation for the purpose of developing a system of barge and ship canals. He says:

> We feel that we may properly expect assistance from the Government, perhaps to the extent of 50 per cent, in the development of these resources in which we are showing our own faith through contributing our own money. With the extreme agitation directed against the "pork barrel," we feel that perhaps this general idea may be the solution of the "pork barrel" question, and may be extended over the entire country, possibly modified so as to apply even to public buildings.

We may add that the "federal aid plan" has already been applied in the recent federal appropriation of $75,000,000 for road building, also that the Mississippi Levee Association is similarly asking federal aid in the building of levees and drainage of lands. But, as Mr. Hills pertinently suggests, why not extend the federal aid plan to other public works, even to post office buildings and harbors? Why not make all federal appropriations for work that is of peculiar benefit to any locality dependent on the financial aid rendered by that locality?

We firmly believe in a broad national policy in the development of highways, canals, drainage, and irrigation. Great corporations apply broad policies of this sort. Look at the Bell Telephone System, for example. It expends hundreds of millions of dollars in plant that serves small towns and farms, with the certain knowledge that it will be 10 to 20 years before the local net revenue from that plant will yield a fair return on the investment. Shall the government of the United States be less broad in its policy than the American Telephone and Telegraph Co.?

Men who have developed great railways have invariably pursued the policy of building lines far in advance of immediate needs, and for what? To develop the country tributary thereto. Those who use the older parts of those railways actually pay most of the freight over the new lines, even on goods that they themselves neither ship nor receive. Yet what sane business man has ever objected to being thus taxed? Business men know that it is wise to sacrifice money temporarily, if the sacrifice is likely to result in a greater general prosperity in which they will ultimately share.

Engineering and Contracting has no patience with the editors of certain daily papers who, in spite of the fact that they have been shown how the "pork barrel" has been eliminated from the national roadwork by the "federal aid plan," still persist in criticising federal aid on the ground that the older states pay more than "their share" of the taxes. If all editors and all politicians were of the calibre of Theodore Vail or James J. Hill there would not be a public word in opposition to federal aid in road building, nor in opposition to other public works projects essential to the general development of this country.

"IF THE GERMANS HAD THOROUGHLY UNDERSTOOD IRRIGATION THEY WOULD NOT NOW BE STARVING."

The statement that forms this caption was made by the publicity agent of one of the great pump companies in the course of a recent talk with the editor of Engineering and Contracting. This publicity agent is a particularly well informed man, so his reasoning to back up his belief should be of more than ordinary interest.

He stated that the potato crops in Germany have been admitted to have been sub-normal since the great war started, and that the shortage has been due to insufficient rainfall at the proper times. With irrigation, as has been demonstrated in America again and again, not only is a crop insured but its abundance is greatly increased. In many cases the yield of potatoes per acre has been doubled by irrigation. In all cases the yield has been very materially greater as a result of irrigation, even in so-called humid districts. Apparently the Germans have not fully appreciated the worth of American experience in irrigating garden truck—potatoes, etc.—or they would have spent more time making pumps and pipe than making Zeppelins.

In a nutshell this expert of a big pumping company—a man who has been gathering irrigation data for years—asserts that a campaign of irrigation in Germany, even if begun after the war started, might have entirely changed the outcome of the war. We must admit that there is more than mere speculation back of this suggestion. In fact, the evidence all points toward the soundness of the contention that irrigation of German crops would have so increased the yield as to have eliminated the present shortage of food.

It should be remembered that America leads the world in agriculture, and that in irrigation by pumping its leadership is unquestioned even by those who insist that America is behind Europe in "intensive farming." By the sophistical method of comparing our average yield of grain per acre with that in Europe, it has been frequently attempted to prove that America has much to learn in agriculture from Europe. But the fact is that not the yield per acre but the cost per bushel should be the final criterion of efficiency in grain production. Judged by that criterion America has led every nation on earth ever since McCormack developed his first harvester.

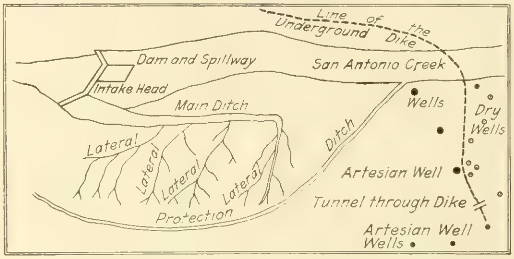
Following our remarkable inventions of labor-saving machinery for the farm came the equally remarkable scientific and educational work of the U. S. Department of Agriculture. Scientific biology wedded to scientific machinery have put America ahead of every nation in the world in the art of raising, harvesting and hauling foodstuffs.

Let us give every other nation its due credit. Let us take off our hats to the Germans as chemists and as military men, but let us be in no haste to humble ourselves when agriculture, manufacturing, mining and transportation are mentioned. In those branches of human endeavor we are pre-eminent today, and long have been.

WHY NOT STORE FLOOD WATER UNDERGROUND?

This question has probably been asked by many irrigation engineers. It had never had an affirmative answer backed up by confirmative acts until, during 1915, the engineers of a company in Southern California "turned the trick" by storing 18,000 acre-feet of flood water underground.

Pomona Valley, at the foot of the Sierra Madre Mts., is watered by San Antonio Creek. This creek runs through a deposit of gravel and boulders. At times it is almost dry, and at times a torrent. Crossing the bed of the creek, and extending to high ground on both sides, there is an underground ridge of clay, forming a natural underground dam, as shown in the accompanying sketch.



It was decided to utilize this underground dam for storing the flood waters of San Antonio Creek. Accordingly a concrete diversion dam was built from which a main ditch (about a mile long and quite wide) led into laterals that were so placed as to distribute the flood waters over 600 acres. This work cost only $50,000, but note the result: With an operating expense of $2,200 for 1915, there were stored 18,000 acre-feet of flood water. The water table was raised about 50 ft., thus greatly reducing the cost of pumping the underground water for irrigation. Fully one-third of the water thus stored was pumped and used to assist in irrigating about 12,000 acres.

There are many localities where this method of underground storage of flood water is applicable, provided underground dams are built. By digging a comparatively narrow trench and filling it with "puddle," it is evident that a cheap underground dam can be made even where the depth to an impervious stratum is considerable.

Is not this plan applicable on a vast scale near the headwaters of many rivers? Indeed, may we not some day see the underground dam used extensively as a means of storing water in all valleys whose soils are sufficiently porous to hold a fairly large per cent of water?

Certainly the success of this initial experiment in Pomona Valley opens up most suggestive lines of thought.

A WATER WORKS APPRAISAL IN MAINE SETTLED WITHOUT A "THIRD ARBITRATOR."

It is a unique spectacle to see two "arbitrators" in an appraisal agree on the total value of the property of a water company. Indeed we find no record of such an agreement between two arbitrators in the valuation of the plant of any public utility company, prior to a valuation made last year by W. B. Getchell and Frederic H. Fay. The first named engineer acted as arbitrator for the Maine Water Co., and the second named engineer acted for the Bath Water District, Bath, Me.

In the contract between the trustees of the Water District and the company, this unusual stipulation is found:

> In the event of a disagreement between Messrs. Fay and Getchell, they are to select a third person as arbitrator, such person not to be an engineer by profession.

The unusual feature of this stipulation is the exclusion of an engineer as third arbitrator. But the more unusual result of this contract is what we wish to point out—the agreement as to the value of the property without the calling in of a third arbitrator.

Engineers frequently can agree on the cost of reproducing a plant, but they usually disagree on the accrued depreciation or the "going value" or both. These two engineers agreed on a total reproduction cost of $559,008, and then they agreed on a value of $539,500. Apparently they allowed very little, if anything, for "going value."

In the first report of the Trustees of the Bath Water District we read:

> This award of $539,500 was therefore $19,507.68 less than the agreed reproduction cost, and therefore necessarily includes nothing for going concern value.
>
> A comparison of this result with the awards made in other cases as the outcome of prolonged and expensive litigation, shows that these awards have averaged about one and a half times the reproduction cost, while in the Bath case, for the first time in the history of the many important water takings in the State of Maine, an award was made without litigation of actually less than the agreed reproduction cost.
>
> The following table will illustrate this unique feature of the award in our case, and while only Maine cases are used for comparison, similar ratios prevail in water cases in other New England states.

Town.	Award.	Ratio of award to reproduction cost.
Gardiner	$ 245,000.00	1.85
Waterville	503,475.37	1.74
Brunswick	196,162.09	1.24
Augusta	427,135.20	1.50
Kittery	163,869.00	1.60
Livermore Falls	117,698.00	1.38
Portland	2,539,235.00	1.53
Portland (Standish W. & C. Co.)	1,313,798.00	1.41
Bath	539,500.00	.99

> Until human nature is changed, the seller will always hope for more and the buyer look for less, and it is therefore highly gratifying to be able to truthfully say, that a result arrived at in a way at once so simple and so unprecedented, proved satisfactory to both parties.

The report commends very highly the work of the appraisal engineers. Mr. Walter F. Abbott, Superintendent of the Bath Water District, writes us that this is believed to be the first waterworks valuation case in New England that was settled without court proceedings. He adds:

> We would also advise that the engineers on both sides used copies of Engineering and Contracting as reference in making the reproductive cost.

Elsewhere in this issue we give the appraisal in detail, and the estimated lives of some parts of this plant.

A SUGGESTED PRESS BUREAU FOR THE NATIONAL ENGINEERING SOCIETIES.

Now that engineers have begun to awake to the opportunities for securing general publicity for the work that engineers are accomplishing, may it not be wise for the national engineering societies to organize an "engineering press bureau"? This is the very suggestive question that is put by "The Valve World" in an editorial from which we quote as follows:

> Why wouldn't it be a good thing to have a well-equipped press bureau at 29 West 39th Street, New York—the home of our national engineering organizations?
>
> There is not a newspaper of good repute in the United States that would not welcome copy sent out by such a bureau, provided, of course, that it was written so that the average reader could understand it. And as for topics, surely there is not a day passes that this tremendously active center of engineering intelligence is not making some of the "livest copy" to be found anywhere.
>
> Have the engineering societies considered this matter? If not, will they look into it? To keep the public informed of the progress in the various branches of engineering through popularly and concisely written features in the daily press would do more to hasten the day when the engineer shall come fully into his own than any other thing that could be devised.
>
> The expense of such a bureau would not be great and the benefits would be beyond calculation. There is not a problem in engineering that could not be made plain to the general newspaper reader; and to have the public understand what is going forward in the engineering field would be of the highest value, especially now when problems of such vast moment to the nation are pressing for prompt and sane solution.

EDITORIAL COMMENTS.

We venture to say that relatively few water works managers know the unit costs of the different kinds of construction and maintenance work done under their direction during the past year. A common excuse is that the amount of work done does not warrant installing a cost system. Doesn't it? Add up all the money expended under your direction during the past five years. Then assume that you might have saved 20 per cent of it by more careful analysis of the costs during the time they were being incurred. Then ask yourself whether it would not have been worth while investigating ways and means of keeping records of the unit costs. Don't imagine that you are an exception and can keep costs to a minimum without knowing what the unit costs are. Rarely has anyone ever applied a good cost keeping system and studied the results systematically without finding ways of reducing the costs more than 20 per cent.

Some time ago we suggested that trench digging machines might be effectively used in the European war. At a recent meeting of the Illinois and Iowa sections of the American Waterworks Association, Mr. A. E. Miller, of Des Moines, read a paper on the use of American trench diggers in France and Russia. He was in charge of the erecting and testing of the machines, of which 22 were shipped to Russia, arriving at the front in October, 1915. They were gasoline driven excavators designed to cut 6 ft. deep and 3.5 ft. wide. So one more American invention is added to the long list of implements that have made this world war so remarkable.

In a recent discussion of a paper read by Mr. E. W. Pittman before the Engineers' Society of Western Pennsylvania, on the factors affecting costs of structural shopwork, Mr. George H. Danforth, Structural Engineer for Johnes and Laughlin Steel Co., said: "Some designers seem to think more of building a monument or of establishing a reputation for a wonderful design than they do of making a simple piece of work that can be readily built of easily available material." True, alas too true even of many engineers, but, let us be thankful, true largely because architects have influenced or even directed them to design for glory rather than for economy.

At the close of the fiscal year, June 30, 1916, the federal Department of the Interior was able to announce that 41 per cent of the total area of the Unied States had been topographically mapped. Yet at that time the surveying technical force numbered only 176 men in the field. In addition 70 technical men were engaged measuring stream discharge, underground water investigation and other work relating to water resources. How ludicrously inadequate are these technical staffs and the miserly appropriation of $150,000 for the year's work! Let the engineers of America speak up and speak together on matters of public economics like this, if real progress is to be made.

The salaries of the engineering employes of the city of Chicago have remained practically stationary for 20 years. A petition to the mayor and council, signed by these employes, call attention to this fact, also that since the necessities of life cost fully 50 per cent more than they did 20 years ago, an increase of salaries should be granted. During this same 20-year period wages of other employes of the city have risen enormously, thus: Common labor, 220 per cent; skilled labor, 83 per cent; foremen, 51 per cent. The average foreman receives only slightly less than does a civil engineer belonging to the highest paid group of engineers. It has ever been thus with democratic governments, to pay those that are "strong in the back and weak in the head" disportionately high. Votes count for more than efficiency.

THE ECONOMY OF KEEPING WATER MAINS CLEAN.

To the Editor: Among the interesting things in your issue of January 10 is an editorial on "The Economy of Keeping Water Mains Clean." You say, "if the inside of every iron pipe were suddenly made visible by some X-ray, what a housecleaning water works managers would order at once." I think this understates the case. A few days ago in company with a well known hydraulic engineer we tested a 6-in. main which had been laid in 1892, and on examination of the bore of a piece of pipe that had been removed decided that its discharging capacity was probably reduced as much as 25 per cent. A simultaneous test of the flow was made by means of a Crown meter and a pitot tube, which gave a very close agreement. The difference in head was measured by means of test gages in a section 1,300 ft. long. In Chezy's formula the coefficient was found to be approximately 28.

The pipe was then cleaned and a similar test made for the flow, and the coefficient was found to be increased to 127; in other words, the flow was more than quadrupled.

This is not by any means an exaggerated condition, but it simply illustrates the great effect of even slight tuberculation in reducing the effective capacity of cast iron pipes.

J. W. Ledoux, Chief Engineer,
American Pipe & Construction Co.
Philadelphia, Pa.

CO-ORDINATED DEVELOPMENT OF WATERWAYS.

To the Edtor: A meeting called by the Board of Trade of Sanford, Fla., was attended by delegates of 18 counties in the State. The purpose of this meeting was to take the first steps toward the creation, by special act of our next legislature which meets in April of this year, of a navigation district comprised of the 18 counties in question and having for its purpose the development of 12-ft. waterways along the east coast of Florida from Jacksonville to Key West; the inland water route recommended by the army engineers up the St. John's River from its mouth past Jacksonville and Sanford to Salt Lake and thence west to the Indian River and Atlantic Ocean at Titusville on the east coast of the State; a connection from the St. John's River to the Kissimmee River and thence down the Kissimmee River into Lake Okeechobee; a cross-state canal from the Atlantic Ocean to the Gulf of Mexico, by way of the State Canal, discharging from Lake Okeechobee into the ocean at Stuart, on the east coast, across Lake Okeechobee and down the Caloosahatchie to its mouth on the Gulf of Mexico below Ft. Myers.

We, who are interested, are of the opinion that this is the first time that any large portion of a State has proposed to organize itself in a legally constituted public corporation for the purpose of developing its own highways for water-borne commerce. We feel that we may properly expect assistance from the Government, perhaps to the extent of 50 per cent, in the development of these resources in which we are showing our own faith through contributing our own money. With the extreme agitation directed against the "pork barrel" we feel that perhaps this general idea may be the solution of the "pork barrel" question, and may be extended over the entire country, possibly modified so as to apply even to public buildings. We also feel that the development of a large district of this kind under a central head should result in a co-ordinated development of all the waterways included therein and, by making possible interchangability of traffic on the entire system, prevent the one cause which has so worked against the usefulness of our national waterway system.

At this meeting in Sanford definite steps were taken toward the securing of the proper legislation through the appointment of a central committee of seven members with C. A. Walker of Sanford, Fla., as chairman, and M.A. Kilvert, Heard Bldg., Jacksonville, Fla., as secretary. This committee will appoint a county committeeman in each of the 18 counties to be included in the district and these county committeemen in turn will appoint such members of their sub-committee as they may desire to assist them.

Great enthusiasm for this project has developed in the State and as it is purely a local measure even though it embraces a third of the State of Florida, and that much of the richest portion of the State, it is believed that the legislature will enact the necessary bill.

P. A. VansAgnew of Jacksonville, Fla., is a member of the central committee in charge of legal affairs, and the writer is special advisor to the committee in a professional capacity.

George B. Hills,
Engineer Manager,
Jacksonville, Fla. Isham, Randolph & Co.

LOGIC FOR ENGINEERS.

To the Editor: In the "Planning and Management" quarterly number of "Engineering and Contracting," dated Jan. 31, I have found the first number of a series of articles announced on "Logic for Engineers."

I read this article with great interest. Having been an editor myself, and knowing how good it feels to have a few words of encouragement when one does a good piece of work, it seemed that I ought to write you to compliment you on this article. The article shows that you have made good use of the "odd hours" which have been devoted by you to the study of logic. You have introduced some modern ideas and concepts of which the science of logic was in need. Reading between the lines, I see that you have discovered, as I have, in reading on this subject, that it was sadly in need of revision, and that there is a great deal of nonsense which has found its way into the so-called "science of logic" between the days of Aristotle and those of Kant that ought to be brushed aside, so as to divest the subject of meaningless verbiage, or the attempt to explain words by other words. The way in which you dispose of Kant, incidentally, in the three paragraphs at the top of page 98, is extremely refreshing and stimulating to anyone who has tried but failed to find out what Kant really means, or to make out whether Kant himself really knew. You say very little about Bergson, but enough to indicate that you are not hynotized by his metaphysics. Perhaps, like myself, you have reached the stage where you are no longer hypnotized by any metaphysics, because you have come down to the earth and prefer to remain in close touch with the same.

My own amateur incursions into the realms of logic have been made in connection with the study of mathematics and of mathematical philosophy. The writers who touch on that branch of logic, like Duhamel, Combe, Jevons, etc., are usually more conservative and cautious in making flights into the realms of metaphysics, and so I have not, perhaps, observed and noted as well as you seem to have the flaws and foibles of their philosophical reasoning and of their methods of analysis. You deserve great credit for placing the results of your studies and cogitations on this matter at the disposal of an audience composed of engineers and technical men, who, in the first place, are sadly in need of information and instruction on that subject and who, in the second place, may prove to be (let's hope they will!) duly appreciative and intelligently receptive of the mental pabulum which you purpose to serve for them.

I sincerely hope that you will bring out your articles in book form. They promise to be too valuable to be treated as if they were merely of transitory interest, like the news of the day. Besides, there are many persons who, like myself, will prefer to read them connectedly at one or two sittings instead of reading them in sections, and being stopped at an interesting juncture by the words "To Be Continued."

C. O. Mailloux,
Consulting Engineer.
New York City.

[Dr. Mailloux, former President of the American Institute of Electrical Engineers, truly says that appreciative words encourage an editor to a degree that few who have not been editors themselves are likely to understand. Men in most professions come directly in contact with those whose interests they serve; and through such contact they are usually able to judge whether their services are appreciated.

Editors, however, do not ordinarily touch elbows with their true employers—their readers. In consequence they frequently have only their own past experience to guide them in determining the sorts of articles that are likely to "fill a want."—Editor.]

VALUATION OF SEWERAGE SYSTEMS.

Contributed by Clinton S. Burns,* M. Am. Soc. C. E.

The general principles involved in the appraisal of sewer systems are not unlike those applicable to the valuation of waterworks or other public utilities, but many special problems arise in connection with the subject of sewerage appraisal, some of which are of sufficient interest to be worthy of attention.

It can doubtless be stated without fear of challenge, that the primary motive in the organization of any private company or corporation is to reap the benefits of the anticipated profits from operation, with the possible exception, in rare instances, where a public utility such as a waterworks or sewer system is built and operated for the indirect benefits accruing from the promotion of land sales, as exemplified particularly in new town site schemes and suburban additions developed for attractive home sites tributary to the larger centers of population.

While the primary motive in nearly every instance is the hope of anticipated profits, this hope is always based upon the fact that the utility must serve a public demand; and in the case of a system of sewers this public demand is based upon convenience and public health. In the vast majority of municipally owned sewer systems, the construction cost is financed upon some system of special benefits or by public bond issue such that the system is operated without further cost to the individuals, thus making public health and convenience the paramount reason for its existence. The privately owned system, on the other hand, having for its paramount reason for existence, the realization of profits, must continually battle for existence against its rival, "Public Health and Convenience," until the inevitable happens and the public requirements must prevail. It is at this point that the service of the expert appraiser is required to make a valuation of the privately owned sewer system.

Discarded Property.

Such a valuation must necessarily involve a study of the requirements of the public, and the design of a sewerage system adequate for the future, including such sewage disposal and purification works as the local conditions may necessitate.

This is important for the value of a sewer system is probably more vitally affected by future public requirements than almost any other class of public utilities, and herein lies one of the principal points special to sewerage valuation work. It seldom happens that any very considerable portion of a waterworks property, electric light, or gas works cannot be utilized in such a rehabilitation of the plant as may be desirable for future service, which is equivalent to stating that the functional depreciation is relatively unimportant in that class of utilities. But in a study of a large number of privately owned sewer systems that have been appraised, not one instance has been found where the system had not suffered relatively large functional depreciation owing to the fact that the sewers had been installed originally to serve a small territory usually beginning with the principal business district, and later extended to such of the residence districts as were conveniently available topographically; and seldom does the design permit of extensions sufficient to meet present requirements of public health and convenience, to say nothing of the future requirements.

The writer is fully in accord with the principle that a public utility property should not be charged with theoretical accrued depreciation to cover obsolescence or functional depreciation of a speculative nature, or beyond that which is reasonably in evidence. But there seems to be no escape from the conclusion that depreciation that has actually occurred, whether it be due to actual decay of structures, obsolescence or functional shortcomings, making it necessary to discard certain parts of the property, must be considered in fixing fair value as a basis of purchase or condemnation by the municipality.

Economic Value.

The economic value of a property is independent of its ownership, and likewise independent of whether a change of ownership is contemplated, or whether the same party is to retain the property; independent likewise of whether the property is owned by an individual or by the municipality. It is therefore apparent that when the question of public health and convenience becomes paramount, the engineer can determine the economic value of the existing sewer system by making a proper design of a sewer system adequate to serve the public, and incorporating the existing system into the rehabilitated system to the maximum degree possible. Then whatever saving in cost of the rehabilitated system is accomplished by being able to utilize the old system in whole or in part, where otherwise a new system would be required throughout, represents the true economic value of the existing property, from the public point of view. And if it be granted that public health and convenience be paramount to private gain, then the value from the public point of view becomes identical with value from the private owner's point of view, because if the private owner be required to give adequate service, he is of necessity confronted with the same expenditure as indicated above, resulting in the same economic value of his existing property, namely, the sum that its existence will save him in cost of rehabilitation. There is, therefore, no conflict between this theory of valuation and the common law requiring that the value of what the owner loses shall control in condemnation proceedings.

It is obvious that this method of determining economic value takes into account all obsolescence and functional depreciation. It is likewise obvious to engineers experienced in sewer design that the elements tending to cause obsolescence and functional depreciation are much more likely to be encountered in sewer appraisal than in any other class of valuation work.

In one specific instance in the writer's experience, it was found that a private sewer system had served the original business district adequately for a time, but growth of the city had made extensions necessary until finally the city was confronted with the necessity of having a new system constructed. In order to serve the new territory demanding service, it was necessary to parallel the principal mains with deeper and larger sewers to afford outlets for the new territory, and many of the existing laterals were found inadequate to admit the sewage from the new territory in the natural and economical way. It is therefore evident that a large obsolescence factor was reflected into the valuation, and this same loss in economic value would be present whether the system were to be acquired by the city, or rehabilitated by the private owner. It has a parallel in waterworks valuation, when a water supply is found inadequate and the investment therein must be abandoned. It must take its place with any other form of discarded property. However, the engineer must use extreme caution to so plan the rehabilitation work as to utilize the existing system to its maximum degree, or he will fail to find the true economic value of the property.

It should be pointed out that nearly all sewer systems that are of the size likely to be encountered in valuation work are usually of vitrified tile, which barring accident, is a permanent material not subject to physical depreciation; and the auxiliary structures are usually of brick masonry and cast iron, which are also practically imperishable. Hence the only depreciation likely to be encountered in an old sewer system to any appreciable degree is that due to obsolescence or failure to perform its proper function of serving the public in an adequate manner.

Functional depreciation in sewerage frequently results from requirements of public health demanding the installation of modern purification works in situations where the old work cannot be economically adapted to the new requirements. This may affect only certain portions of the property, such as main outlets, bulkheads or old sewage treatment works, or it may be more general and vitally affect the system as a whole, reversing the general scheme of sewage collection and disposal.

While the method suggested above, of determining the saving in cost made possible by utilizing the old system to its maximum degree may seem like an easy process, yet in practice it is not as simple as it seems, involving as it does, the question of applying the proper time element to the remaining useful life of individual units of the old system. Care must be taken also to include a proper allowance for interest during construction and other overhead charges in all portions of the old property incorporated into the rehabilitated system, in order that the true comparison will be reflected into the economic value.

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*Burns & McDonnell, Consulting Engineers, Kansas City, Mo.

Cost of Reproduction.

The economic value of the property may not, however, represent the fair value that should be used as a basis of municipal purchase of a privately owned sewer system, for reasons that will appear later. It is, therefore, important that the valuing engineer should make an accurate estimate of the cost of reproduction of the existing system. The general theory favored by the writer is that reproduction cost should be based upon physical conditions not necessarily as they originally were, but rather as they would now be encountered if the property were now to be constructed for the first time.

Field Data.

It seldom happens that maps or profiles of an old sewer system are available to the valuing engineer, as the usual situation encountered is that the original system was built without adequate plans, or else the plans have been lost. The field party is therefore obliged to reconstruct the profiles by examination of the sewers through manholes and other appurtenances, thus determining the size of the sewers, the elevation of the inverts at all manholes, flushtanks, etc., and frequently it becomes necessary to excavate test pits to locate sewer lines where manholes are lacking. The labor involved in relocating an old system of sewers, inadequately recorded, is invariably much greater than to perform the field work for an entirely new system covering the same territory, and needless to say, it is far from an aggreable or pleasant engagement for the field engineer who makes the internal measurements, particularly in the sections of the country where beetles and cockroaches abound, and where hornets build their nests just under the manhole covers.

Test pits, soundings, or other means must be employed to determine the nature of the soil and rock classification, with the same care and accuracy as though estimates were to be made for a new system. Effort must be made to secure all possible data bearing on the history of the original construction, in order that everything having a material bearing on the estimates of cost shall be included and taken into consideration.

This is particularly important in regard to determining original soil conditions encountered in the sewer construction. It frequently happens,—in fact it may be stated as a general rule,—that the building of a sewer system in wet soil results in a marked reduction of the ground water elevation, and unless the original condition in this regard be known, the estimated cost of reproduction will always be in favor of the purchaser and work a hardship upon the owner to whatever extent the original ground water would prove to be a factor in the cost, were it still present at the time when reproduction estimates are made. It is doubtful if this particular factor enters into any other class of valuation work to the extent that it does in sewer appraisal.

The collection of cost data requires the same general procedure for sewer work as for any other appraisal and need not be repeated here.

Office Details.

Upon completion of the collection of field data the results of the surveys are platted in the customary manner, showing the map of the territory sewered, profiles of the ground surface, rock and soil profile, and gradient of the sewer, and showing also all manholes, lampholes and other appurtenances the same as would be required in a set of working drawings for a proposed system of sewers From these profiles a bill of material is prepared as a basis of the cost estimates. The unit cost data is then assembled and applied to the quantities comprising the bill of material, thus giving a basic physical cost the same as would be obtained for a new system of sewers identical with the system under review. This basic cost should include the usual and necessary overhead costs, such as engineering, preliminary investigations, legal fees, interest during construction, contractor's profit and such contingencies or other costs as experience shows to be proper for the class of work involved.

Going Value.

Business development cost and going value are then determined upon whatever basis seems most equitable under the circumstances applicable to each case. Private sewer systems are sometimes found operating on the "mutual" plan, built and paid for by the property owners of a certain district and operated without profit or loss, assessments being made from time to time just sufficient to cover the expenses of operation and maintenance, but seldom providing anything for deferred maintenance.

So far as the writer is aware, no method has ever yet been proposed by which going value or business development cost can be computed where a property is financed as above indicated, on the "mutual" plan. In this case the private owners and the rate payers become one and the same, and being identical, their interests become identical.

The business development cost being fully paid by the patrons in full from the very inception of the enterprise, there can be no deficiency from operation that would appear as development cost, and the cost of the service is represented by, and is exactly balanced by interest, operation, etc. Hence, unless the cost of the service exceeds its reasonable value, which would be very difficult to determine in the case cited, there can be no showing of business development cost in the usual sense in which that term is employed.

Going value on the other hand is, in the writer's opinion, a positive quantity always to be taken into account in a business in successful operation and earning revenue, the amount of going value being dependent upon the value of business and revenue derived therefrom. If a property is earning just enough to pay maintenance, operation and depreciation, the going value is moderate, but manifestly greater than if there were no business at all and no revenue. Interest is omitted from consideration in this case, the principal having been paid in advance by the consumers, which is equivalent to including interest in annual assessments.

Having now completed the estimated cost of reproduction of the identical system under review, including its business development cost and going value, comparison can be made between the cost of reproduction and the economic value found as explained heretofore. The same amount for business development and going value should be included in the economic value as in the reproduction cost. The difference between the economic value and the reproduction cost represents the sum total of all classes of depreciation, physical, functional, and that due to obsolescence.

The Fair Value.

The question now arises: How shall the depreciation thus determined be treated in order to deduce the fair value of the property? What portion, if any, of this functional depreciation and obsolescence shall be borne by the owner and what portion by the purchaser? Referring again to the mutual company above cited, if it be found that the sum total of all classes of depreciation is greater than has been paid in to cover the element of depreciation, then this shortage would automatically take its place as development expense, and it would thus seem that the depreciation to that extent at least should be assumed by the purchaser in the interest of fairness and equity to all parties. Again, considering the small district served by the private sewers as a single unit, it would not seem equitable to depreciate that property solely because the whole community, or a larger district, considered as a single unit, might be more efficiently served by making radical changes in the sewers already adequately serving the smaller community. So, again, from this angle it would seem that functional depreciation and obsolescence should be assumed by the purchaser to the extent, at least, that it is caused by the requirements of the purchaser, or is desirable in the interest of the public welfare of the whole community and against the interest of the smaller unit of the community. This principle should hold true whether that smaller unit be a previously developed mutual company, a single individual, or a corporation.

For the reasons indicated above, no general rule can be stated that will apply equitably to the various conditions, and the valuing engineer must, therefore, ever keep an open mind and weigh the particular circumstances encountered in each case, taking precaution that his final analysis will result in a valuation that shall be equally fair to the public and to the private utility.

The Public Interest.

Probably in no other privately owned utility is the public as closely concerned as in the case where sewers are thus owned and operated for profit.

Statistics collected from the various states where privately owned sewers are prevalent, show the evils of such a practice in many instances. A statement from the engineer of a State Board of Health, in one case says of the practice:

> Where private sewers are installed such a procedure operates to defer the installation of a properly designed and constructed sanitary sewer system. It is also true that temporary private sewers as the same occur in our state have rarely been constructed in a sanitary manner, and as a rule cannot be incorporated in any new sanitary sewer system, although in a few towns such construction has been available in the new system later installed.

Another State Board Engineer reports:

> In the towns of this state where private sewer systems have existed, their presence has delayed the construction of municipal sewers in the residential portions of the city for a number of years. There is no question in my mind but that they are distinctly baneful in their effect in that particular. Business men who were being served by these private sewers, and with whom oftentimes they had long-time contracts, were, as a rule, opposed to the establishment of municipal sewers, and as the business men of the community usually dominate its policy, the result was that the establishment of a complete sewer system was from time to time deferred. Moreover, these private sewer systems were cheaply constructed and were entirely inadequate and could not be made a part of a complete municipal system on account of their size, location and grade. From the very fact that the most dangerous place in any community is the unfly-proofed outside toilet containing dangerous human excrementitious material, any condition that will handicap or delay the establishment of a complete sewerage system for a city for the proper disposal of its dangerous material, must be considered a distinct health hazard and liability to that city.

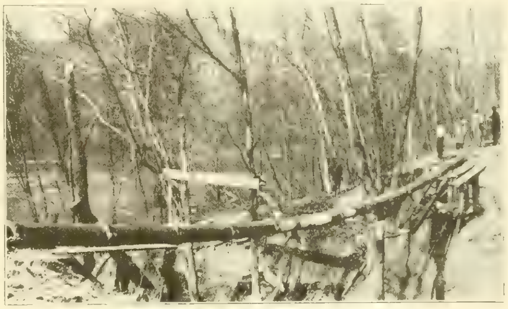
And these quotations are merely representative of the universal experience on this subject.

Conclusions.

1. Every legitimate effort should be used to discourage the building of private sewers.
2. Any city or town large enough to support such a system, is amply able to construct a municipal system designed along proper lines.
3. Private sewers heretofore constructed, should wherever possible, be taken over by the municipality and incorporated into a general plan of sewerage adequate to give efficient service.
4. The fair value should be allowed for every such property, for every attempt by any municipality to do otherwise, reacts to discourage progress toward the desired end, viz., the advancement of public health.
5. Modern sewage disposal plants are most commonly being recognized as essential to the betterment of health conditions and as this part of a sewer system is non-revenue producing, the private owner naturally resists any efforts on the part of the city or state officials toward requiring modern disposal plants, hence an improvement in health of communities is often retarded.
6. If state laws limit the bonding power and prevent cities from installing their own sewers, making an appeal to private parties necessary, then this evil legislation should be promptly corrected.
7. From records of a large number of sewer appraisals made by the writer, it is found that in cities of the same population the municipally owned sewers cover from three to four times the area covered in privately owned sewers. It is, therefore, clearly apparent which cities would possess the more modern homes with their greater conveniences in living and a higher standard of public health.

PIPE LINE INTACT DESPITE DAM WASHOUT.

A striking example of the dependability of cast iron pipe lines composed of short lengths and having flexible joints, is given in the almost unparalleled incident which occurred at Holt, Ala., during high water in the Warrior River and its tributaries. The photograph shows part of a 1,400-ft. line of 12-in. Class No. 100 Universal pipe laid across the top of a dam as it appeared after the dam was washed out by a freshet. The pipe settled as shown, but all the joints remained intact and while the dam was being rebuilt the line was kept in service supplying water for a large coke oven plant.


Unsupported Pipe Line at Holt, Ala.

The 16 lengths of pipe affected, of which 12 were entirely without support, showed a maximum settlement or deflection of 46 in. at the center of the line.

A NEW WATER AND LIGHT ASSOCIATION.

The Water and Light Society of Mississippi was organized Jan. 15 at Jackson, Miss. The society has for its object the design, improvement, operation and efficient management of the publicly owned water, light and power plants of the state. The membership is not necessarily, as its name would indicate, confined to the State of Mississippi, nor is it intended to limit its membership to those plants which are municipally owned. All superintendents, managers, engineers, both civil and mechanical, who are connected in any capacity with power plants, or who are otherwise interested therein, and may be practicing their profession or engaged in the operation of a power plant, are eligible. There are three classes of membership, Honorary, Active and Associate. The constitution is similar, in many respects, to that of the American Water Works Association, one of the trustees of which association was elected the first president of the society, M. L. Worrell of Meridian, Miss., general manager of the water works in that city. The vice-president is W. W. Pointer, superintendent of water and light plant, Clarksdale; the secretary is Prof. R. C. Carpenter, professor of mechanical engineering in the A. & M. College at Starksville; treasurer, Henry Converse, lessee, water and light plant, Crystal Springs. The affairs of the society are in the hands of board of trustees, two of whom are the president and vice-president, and John T. Sharp, Jr., superintendent water and light plant of Canton; J. A. Steele, Jr., superintendent water works, Vicksburg, and H. E. Johnson, superintendent of water and light plant, Senatobia. Practically every water and light plant superintendent in the state is numbered in the membership. There are also several of the supply houses in different sections of the country in the list of associate members.

WATER-TIGHTNESS OF THE CORPUS CHRISTI PIPE LINE.

Contributed by Alexander Potter, Consulting Engineer, New York City.

The City of Corpus Christi, Tex., last year placed in operation a new water works system, consisting of a pumping station, filter plant, 16 miles of force main, and an elevated water tank of 250,000 gal. capacity.

The force main, 20 in. in size, is designed for a working pressure varying from 130 lb. at the pumping station to about 50 lb. at the water tank. Bids were received for cast iron, steel, and machine-band wooden stave pipe. The following is a summary of the bids received per lineal foot of pipe in place:

Kind of pipe.	Average of all bids.
Cast Iron—	
Class B (American W. W. specifications)	$2.99
Class C (American W. W. specifications)	3.38
Matheson steel pipe, national coating	2.62
Steel pipe—57.3 lb. per ft., coated	2.63
Machine-banded wooden stave pipe with cast iron collars	2.36

Public sentiment at Corpus Christi inclined to favor cast iron pipe, and as the bids for cast iron pipe were unusually favorable the writer recommended its adoption.

The specifications under which the pipe was laid required that from time to time during the pipe laying and wherever possible before the trench is backfilled, each section as completed should be subjected to a hydrostatic test pressure 25 per cent in excess of the maximum working pressure and that under this pressure the average leakage for the entire pipe line must not exceed an average value of 2 gal. per minute per mile per day (equivalent to 144 gal. per mile per inch of diameter), except that in individual sections the leakage might be 25 per cent greater, provided that the permissible average value was not exceeded on the entire line.

The pipe line was tested as completed in sections of about one mile in length. As a rule, water was admitted to the section to be tested from 3 to 30 days previous to the acceptance tests. In addition to the regular air valves installed at all pronounced summits, short nipples were inserted at all minor marked summits and fitted with globe valves to permit the air to escape during the filling of the pipe line with water. As a rule, from two to three such air outlets were provided in each test section.

The equipment for testing consisted of a tank pump with a 4½-in. stroke, 2½-in. bore, and fitted with an air chamber. The pipe to be tested was tapped for a ¾-in. discharge line from the pump, these test holes being plugged later on. All water used for testing was pumped from a barrel which had been carefully calibrated. In the first few tests made the pump was operated by hand, but later on it was found more convenient to operate the pump by power obtained from an automobile by connecting a driving rod from the pump handle to the rear wheel of the automobile raised clear of the ground.

Previous to the pressure test the main had been filled with city water from the existing 8-in. and 10-in. force main, producing a hydrostatic pressure of from 10 to 100 lb. per square inch. Just before the test this connection with the existing main was closed and the test pump started and the pressure raised to 2½ lb. in excess of the specified test pressure, when pumping was stopped and the pressure allowed to drop off 2½ lb. Then pumping was again resumed. As a rule, the tests for leakage were continued under full test pressure for a period of two hours. The total quantity of water pumped into the main during this period was measured and recorded as the leakage of the pipe line.

In spite of the precaution taken to liberate all entrapped air, it is very likely that a very small portion of the reported leakage was due to the compression and absorption of entrained air. The leakage through gate valves was not determined by actual tests, but it is believed to have been very small with the exception of a section near the pumping station where such leakage as was determined indirectly appeared to be considerable.

Because of the precautions taken to have the pipe to be tested filled with water several days in advance of testing, the quantity of water absorbed during the test by the hemp in the joints and the amount replacing the entrapped air lost by absorption or otherwise, was very small.

When operating the test pump by hand it took from one to three hours to raise the pressure in the section of the main under test to that specified. When operating this same pump by power the pressure was obtained in half the time. As a general rule, no backfilling was done previous to testing except where absolutely necessary; nevertheless, a great many joints by the time the section was ready for testing were covered up by the caving of the trenches. Wherever feasible, while a section was under the full test pressure, the section was thoroughly examined for its entire length for leaks of consequence, but few were found. All bad leaks had previously been repaired by the contractor when subjecting the pipe to a preliminary test.

Most of the joints were caulked partly by hand and and partly by machine. In the majority of cases the upper half of the joint was machine-caulked and the lower half hand-caulked. The sections tested on June 7 and Nov. 2 were largely machine-caulked. These sections not only showed up best under the test pressure, but according to the contractor required less work of recaulking than any of the other sections in which hand-caulking was more generally used.

The records show that there was practically no difference in the rate of leakage during the test period lasting an average of two hours.

The following table gives the results of the tests made on the various sections of the pipe line:

RESULTS OF THE TESTS MADE ON THE CORPUS CHRISTI PIPE LINE.

18-in. cast iron pipe—Length of section tested, 14.1 miles.

Date of test..	Length of section (miles).	Total leakage gal./min.).	Test pressure (lbs.)	Leakage (gal. min. per mile).	Gals. per inch-mile per day.
June 2, 1915	1.10	1.10	162	1.00	72
June 4, 1915	0.67	0.98	162	1.45	105
June 15, 1915	1.23	1.08	140	0.88	63
July 15, 1915	1.25	0.85	120	0.68	49
September 8, 1915	1.93	2.79	108	1.45	104
September 11, 1915	1.64	1.92	118	1.17	84
September 28, 1915	1.57	1.50	108	0.96	69
October 20, 1915	1.58	2.34	108	1.48	107
October 27, 1915	1.65	3.06	108	1.85	134
November 2, 1915	1.48	1.55	108	1.05	75
Total	14.10	17.17	...	....	...
Average	.....	.....	...	1.22	89

In the opinion of the writer, the tests made on this pipe line show the degree of water-tightness that can reasonably be expected on work of considerable magnitude. The specifications under which this pipe line was laid, though exacting, are not so severe that the degree of water-tightness called for cannot be obtained in practice under conditions of good workmanship.

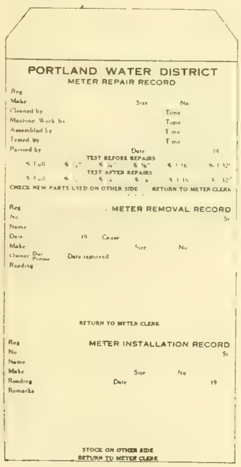
For purpose of comparison there is reproduced herewith a resume of the degree of water-tightness called for by other engineers on other works and that obtained by the writer, both at Corpus Christi, Tex., and at Moorestown, N. J.

Author and location of work	Permissible leakage (gals. per inch-mile per day).
New York Aqueduct specifications	240
J. H. Gregory, Columbus, O., 20-in. pipe	507
J. H. Gregory, Columbus, O., 24 and 30-in. pipe	528
E. G. Bradbury, Akron, O.	100—average 200—maximum on any one section
W. D. Gerber (Ill. Water Supply Assoc., 1913)	167
Alexander Potter, Corpus Christi, Tex., 20-in. pipe	144—average 180—maximum on any one section
Alexander Potter, Moorestown, N. J., 8 and 10-in. pipe	180—average
Actual results obtained at Corpus Christi, Tex.	49 minimum 89—average 134—maximum
Actual results obtained at Moorestown, N. J.	74 minimum 122—average 180 maximum

The laying of the Corpus Christi pipe line was carried out under the supervision of Mr. H. A. Stevens, City Engineer of Corpus Christi, with Mr. C. J. Howard, Assistant City Engineer, in direct charge. To Mr. Howard the writer is indebted for many of the details given herein.

METHOD OF PORTLAND WATER DISTRICT FOR RECORDING SERVICE OF METERS.

The development of the meter department of the Portland Water District of Portland, Me., reached a point in 1916 where it was evident that some means must be devised to relieve the congestion of clerical work in the work shop department. The obvious cause was the manner of recording the different phases of the changes in the life of a meter. The heads of the departments with the general manager then submitted to the engineer ideas for a meter tag. The tag as finally adopted is a three-section perforated Dennison manila tag 8x 4⅛ in. in size, printed on both sides, which folded three times is filed easily in the ordinary office card system cabinet. The front side bears the meter records, while the reverse has the stock used in setting record, and the stock repair parts record, as shown in the illustrations. Figs 1 and 2.



PORTLAND WATER DISTRICT
METER REPAIR RECORD
Reg
Make Size No
Cleaned by Time
Machine Work by Time
Assembled by Time
Tested by Time
Painted by Date 19
TEST BEFORE REPAIRS
% Full % % % % 1/16 % 1/32"
TEST AFTER REPAIRS
% Full % % % % 1/16 % 1/32"
CHECK NEW PARTS USED ON OTHER SIDE RETURN TO METER CLERK

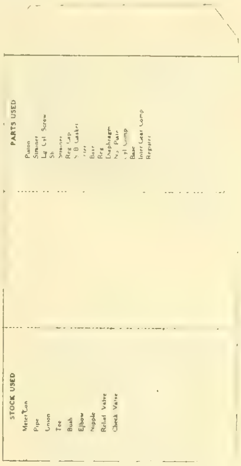
Reg METER REMOVAL RECORD
No St
Name
Date 19 Cause
Make Size No
Owner Dist. Private Date removed
Reading

RETURN TO METER CLERK

Reg METER INSTALLATION RECORD
No St
Name
Make Size No
Reading Date 19
Remarks

STOCK ON OTHER SIDE
RETURN TO METER CLERK

Fig. 1—Front of Tag.



PARTS USED
Piston
Strainer
Lg Cyl Screw
Sh
Strainer
Reg Cap
B Gasket
Base
Reg
Diaphragm
Plate
Base
Inter Gear Comp
Register

STOCK USED
Meter Con
Pipe
Union
Tee
Bush
Elbow
Nipple
Relief Valve
Check Valve

Fig. 2—Back of Tag.

A diagram (Fig. 3) was prepared by the engineer as an instructing method to acquaint workmen with the use and proper channel of the tag. The dotted lines represent the course, and the "M" in a circle is emblematical of the meter. The squares marked 1-2-3 represent the three sections of the tags. At the upper left-hand corner is the meter received from the ractory. The meter clerks in the office make out a tag, and it is sent to the repair department, tied to the meter and the meter is placed on the storage shelf. The tag bears at 'his time, "make, size and number."

An order to set meter is sent from the office (this order later becomes the charge slip for the meter). The meter, tag and all, is taken from the shelf and sent out to be set; the tag with its three sections is now returned to the meter clerk, having only the addition of the name and street address of the place of setting. Number 1 section is detached and filed, and the other two sections now are filed as they represent the removal tag or order, to be used later.

When a meter is to be removed it is only necessary to step to the file drawer, remove the two-section tag, fill in the space marked "cause for removal," and send the order to workshop department. Thus these two-section tags not only represent removal orders filed in register number to agree with the customers' ledger, but they also supply the actual number of meters in service at the present time. After the driver removes the meter at the house he ties the two-section tag to the meter and it is brought to the workshop, the removal tag being detached and sent to the meter clerk. This tag is then filed with the installation tag in the cabinet.

As soon as the meter is repaired, the last or third section of the tag is returned to the meter clerk, who makes a new tag as at the first stage of the cycle. The repair slip is filed with the other two sections and there is a completed cycle in the cabinet. This is the completed cycle for a new set, the only difference for the changes for long services is that the installation section for the new meter and the removal section of the old meter arrives in the office at the same time. This is an important factor, as it prevents any complications in the register numbers.

The dominating feature of this tag is its simpleness and yet completeness. All writing is done by the meter clerk (except the name and address on the installation tag). All records are in easy access in the office file, and all congestion in the workshop department is obliterated. A complete record showing the number of meters in service, the number of times a meter has been in service, in fact all the meter information is at immediate disposal at a minimum expense of time and labor. James Graham is General Manager and Milton Thorne is Superintendent of the Portland Water District.

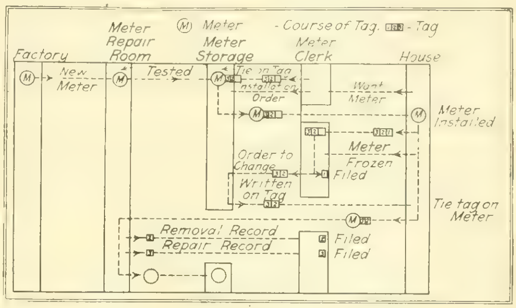


Fig. 3—Diagram Showing Method of Using Meter Tag.

Cost of Operating Sand Catcher.—The east side intercepting sewer at Columbus, O., which receives the drainage from a combined sewerage system, delivers to the station sewage which carries a considerable amount of sand and heavy refuse and a part of this material is removed in a sand catcher whose floors slope to a narrow trough in which an endless bucket conveyor travels. This conveyor is motor driven and is operated at frequent intervals so that the deposits are removed before large accumulations occur. The power cost of operating this conveyor 2,468 times during 1915, acording to the annual report of C. B. Hoover, chemist in charge, was only $2.30 and 3,837 wheelbarrow loads of sand and refuse were removed. The pumps are protected from clogging material by passing the sewage through vertical bar screens set in cages which are placed in tandem and raised and lowered by a motor driven mechanism. The bars in the front screen are 1 in. apart in the clear and those in the rear screen are ½ in. apart in the clear. These screens were raised and lowered 1,347 times during the year with a removal of 4,122 wheelbarrow loads of screenings and at a total power cost of $3.50. The refuse from the sand catcher and screens is spread over waste places near the station and without the production of a nuisance.

About 100 miles of additional track of the Chicago, Milwaukee & St. Paul Ry. have been turned over to electrical operation. This leaves only the third unit of the electrification plant still to be completed. The additional track extends from Deer Lodge to Alberton, Mont., and brings the total of electrified line to 336 miles.

COMPARATIVE COSTS OF CONSTRUCTION AND OPERATION OF ACTIVATED SLUDGE AND IMHOFF TANK-TRICKLING FILTERING PROCESSES OF SEWAGE TREATMENT.

An interesting comparison between Imhoff trickling filter and activated sludge methods of sewage treatment was given by Harrison P. Eddy of Metcalf & Eddy, Consulting Engineers, in a paper presented before the Western Society of Engineers. The discussion was based on studies of treatment plants designed to fulfill the same conditions. The figures for the trickling filter plant were based on the design and cost of the plant at Fitchburg, Mass., with such modifications as were necessary to reduce the costs to units suitable for comparison. The design of the activated sludge plant was based upon experience gained from several experimental installations operated by Mr. Eddy during the past year and from data from Milwaukee and other reports. Both plants were designed to care for the sewage from a population of 55,000 persons. The average quantity of sewage was assumed to be 100 gal. per capita per day, equivalent to 5,500,000 gal. per 24 hours, and the detention period in Imhoff and humus tanks was based upon a daytime flow of 125 per cent on the average. The Fitchburg, Mass., plant has been in successful operation since October 1914. The structural features of this plant were very fully described in the June 25, 1913, issue of Engineering and Contracting. The only material modification made in the Fitchburg design to aid in Mr. Eddy's comparison was to increase the sizes of the trickling filters and dosing tanks to serve a population of 55,000 instead of 40,000 persons. Mr. Eddy's paper is printed in the December Journal of the Western Society of Engineers, from which the following matter is taken:

The plant for the activated sludge process was designed as far as possible to meet the same conditions as those for which the trickling filter plant was built. The same type of structures has been used where applicable, and an effort was made in every way to make the two plants strictly comparable, both being designed to serve 55,000 persons.

The grit chamber, screens and venturi meter equipment are included without change in the activated sludge plant, the requirements being the same in each case.

The sewage aeration tanks were designed to operate on the continuous flow plan. The tanks were rectangular in plan, each unit being 30 ft. wide by 90 ft. long inside, of a type similar to the Imhoff tanks in the trickling filter plant. Compressed air was supplied to the tanks through a piping system leading to a series of filtros blocks located in the bottom of the tank. Each tank unit was divided by means of thin partition walls into four longitudinal channels 7 ft. 2 in. wide. Provision was made for a depth of 10 ft. of liquid above the top of the filtros blocks. It was intended to operate two tank units in series and five double tank units in parallel; that is, the sewage will enter one tank, pass longitudinally back and forth through the four channels in that tank, then to the second tank and back and forth longitudinally through the four channels of that tank to the point of discharge, making a total distance traveled of about 700 ft. Sufficient tank capacity was provided for an average period of aeration of 4½ hours, with sludge capacity amounting to 25 per cent of the total tank capacity. Under these conditions the average horizontal velocity would be about 2.6 ft. per minute. The ratio of total tank floor surface to area of aerating system was 8.5 to 1, which is the basis of the present Milwaukee tanks. The indications are, however, that this ratio should be reduced so as to provide a somewhat larger area for air diffusion.

For the purpose of aeration and agitation it was assumed that the volume of air to be supplied will average 1.75 cu. ft. per gallon of sewage treated.

The quantity of air required to aerate the average quantity of sewage at the rate of 1.75 cu. ft. per gallon treated, will be 6.680 cu. ft. per minute. An increase in rate of sewage flow to 150 per cent of the average will frequently occur and the air compressing plant must be able at all times to meet this requirement. In addition, provision must be made for emergencies of various kinds. For this service four units of electric, motor-driven, positive pressure blowers, were provided, each capable of furnishing about 3,200 cu. ft. of free air per minute at a pressure of about 5 lb. per square inch. The motors must be of the variable speed type, in order that the quantity of air may be varied according to the requirements. Two additional blowers of the same type and size were provided to furnish air for the sludge aeration tanks.

On account of the small pores in the diffusing system, whether filtros blocks, wooden blocks or other means are employed, it is essential that the air furnished shall be clean; that is, free from dust, oil or other foreign substances. One of the best methods of obtaining clean air is to pass it through an air washer before going to the compressor. Such apparatus is a standard commercial product and operates satisfactorily.

The estimates provided for two air flow meters of the General Electric Co. type, similar to those in use at the Milwaukee plant. One of these meters was intended to measure the quantity of air supplied to the sewage aeration tanks, and the other the air supplied to the sludge aeration tanks. In a large plant it may be advisable to install additional meters to measure the quantity of air supplied to air lifts, but in the comparison no allowance was made for such additional apparatus.

A building will be required to house the several air compressor units amounting, in this particular case, to six large positive pressure blower units and two small reciprocating units for operating the air lifts. This building may also house the air washer, air meters, transformers and other equipment.

The estimates included six sedimentation tanks. Each was of the vertical flow type, cylindrical in form with inverted conical hopper bottom terminating in a deep well 4 ft. in diameter, similar to the tanks at Milwaukee. The tanks provided for sedimentation for a period of ½ hour, on the continuous flow plan, with space for sludge amounting to 25 per cent of the total tank capacity. The total depth of water and sludge, in the central well, was 35 ft. The tanks at Milwaukee were constructed with hopper bottoms on a slope of 1 to 1, but experience has proven that steeper slopes are necessary if the sludge is to slide easily into the central well. These tanks were so designed that the sewage and sludge will enter the tank at the center, flow downward and under the edge of the distributing cylinder, thence upward and out through collecting weirs arranged around the circumference of the tank. Each of the central sludge wells will be provided with an air lift to raise the sludge from the sedimentation tanks to the sludge aeration tanks, or into the influent of the sewage aeration tanks.

Two units of sludge aeration tanks were provided of a type similar to the sewage aeration tanks, but differing in that the partition walls were made heavy enough to withstand water pressure, thereby making each channel a separate sub-unit. The general dimensions of channels were the same as in the sewage aeration tanks; that is, 7 ft. 2 in. wide and 90 ft. long, provision being made for a depth of 10 ft. The total capacity of sludge aeration tanks provided is 328,000 gal. which is equivalent to 0.8 cu. ft. per capita, or about 60,000 gal. per million gallons of operating capacity.

It was planned to provide one air lift in a well to serve the eight sub-units of sludge aeration tanks, and a similar lift for each of the sedimentation tanks.

It was estimated that the activated sludge process will produce about 4,500 gal. of sludge per million gallons of sewage. Doubtless this quantity will vary considerably under different conditions. It is largely dependent upon the proportion of water contained in the sludge. For the average quantity of sewage for which this plant was designed, 5,500,000 gal. per 24 hours, the quantity of sludge produced daily will be 24,750 gal. For the purposes of this comparison it was assumed that the sludge will be dried on sand drying beds from which it can be removed to a dump.

It is recognized that important experimental work is being done to develop suitable dewatering and drying processes that will make it economically possible to dry the sludge to 10 per cent moisture and thus make it saleable as a low-grade fertilizer or as fertilizer base.

For the purpose of estimates it was assumed that the sludge drying beds can be dosed an average of 15 times per year to a depth of 12 in., thus requiring a total net area of sludge beds of 80,500 sq. ft. To this should be added a sufficient area to care for sludge during the winter months (Dec. 15 to March 15) and to allow for drawing of water collecting on the surface of the sludge. To provide for these contingencies the area should be increased 50 per cent to 120,750 sq. ft., equivalent to 2.76 acres net area, or 2.2 sq. ft. per capita. If sludge bed units of the same size and type as those for the trickling filter plant, are used, there will be required 77 such units, or about 7 times the area required for the trickling filter process. These sludge beds were suitably underdrained and provided with a system of narrow gage tracks and cars for removing the sludge to the sludge dump whence it can be carried to a point of disposal.

Cost of Construction.

The cost of the trickling filter plant was based on the unit costs of construction of the trickling filter plant at Fitchburg, Mass., which was built by contract, bids being received in May, 1913. Cost figures obtained in this way are more nearly representative of normal conditions than if based on the high cost of construction prevailing at the present time. As far as possible the same unit costs of construction have been applied to the estimates of the activated sludge plant, that the two estimates may be comparable.

The estimated cost of the trickling filter plant is given in Table I. In addition to the main features, a number of items are included which go to make up the complete plant. It should be noted that the amount included for cost of land, includes not only the land required for the treatment plant, but a total area of about 117 acres, sufficient not only for all purposes of sewage treatment, but also more than sufficient to properly isolate the plant. Under miscellaneous work are included such items as extension of the water supply, electric lighting system, and other features of minor importance not covered by the principal items. It is expected that for a plant of this character administration charges may easily amount to 3 per cent and engineering to 12 per cent, making a total of 15 per cent to be added for these items. The total estimate of the Imhoff tank—trickling filter plant for a city of 55,000 population, is $431,710. This is equivalent to $7.85 per capita, or $78,500 per million gallons per day for the assumed flow of 5,500,000 gal.

TABLE I.—ESTIMATED COST OF IMHOFF TANK-TRICKLING FILTER PLANT.

	Cost excl. eng'g and administration. Total.	Unit cost, excl. eng'g and administration. Per capita.	Per M. G. D.
Grit and chamber screen	$ 10,000	$0.18	$ 1,818
Venturi meter chamber	3,000	.05	545
Imhoff tanks, incl. air lifts for sludge	64,500	1.17	11,720
Air compression equipment	800	.01	145
Sludge beds including underdrains	4,800	.09	873
Trickling filters 10 ft. deep (2.75 acres)	188,500	3.43	34,300
Dosing tanks and apparatus	16,600	.30	3,020
Secondary settling tanks	9,000	.16	1,637
Sludge pumping equipment and building	2,000	.04	364
Conduits and pipe lines, incl. overflow	10,600	.19	1,925
Effluent channel	1,300	.02	236
Roadways	9,100	.17	1,655
Laboratory building and equipment	15,200	.28	2,762
Grounds, trees, planting, etc	1,700	.03	309
Miscellaneous work, 4% of total, excl. land	13,300	.24	2,420
Land	25,000	.45	4,550
Total	$375,400	$6.81	$68,279
Add 15% for engineering and administration	56,310	1.04	10,221
Grand total	$431,710	$7.85	$78,500

For 55,000 persons = $7.85 per capita.
For 5,500,000 gal. per day = $78,500 per m. g. d.

The estimated cost of the activated sludge plant is given in Table II. In addition to the features already described, it will be noted that several items have been included to make the plant complete. As stated in the case of the trickling filter plant, the item of $25,000 for land includes about 117 acres. It may not ultimately prove necessary to isolate the activated sludge plant, in which case a credit in favor of this plant should be made on account of the small area of land required. In this case, as in the other, 15 per cent has been added to cover the cost of administration and engineering charges. It will be seen that the total cost of the activated sludge plant is $313,880, which for a population of 55,000 persons is equivalent to $5.71 per capita, and $57,100 per million gallons per day.

Cost of Operation.

An estimate has been made of the cost of operation of the trickling filter plant, based principally on the experience at Fitchburg, for the years 1915 and 1916. From data furnished by David A. Hartwell, Chief Engineer, deductions have been made for certain expenditures pertaining to construction rather than operation. The items for 1916 (with estimates for November, the last month of the fiscal year) are shown in Table III, from which it appears that the total cost of operation has been $11,250, which is equivalent to $10.28 per million gallons treated, averaging 3,000,000 gal. daily, or 35 ct. per capita, on a basis of 32,500 persons actually connected. The total population in 1915 was about 39,656.

Similar figures for the Gloversville trickling filter plant show the following costs of operation per million gallons of sewage treated:

Year.	Annual cost of operation. Per M. G. treated.	Per capita.
1913	$5.16	$0.24
1914	5.92	.27
1915	5.72	.26

It should be stated here that these expenditures are limited to the barest necessities. No chemical supervision nor other refinements which can be avoided, are included.

The estimate of annual operation cost of the hypothetical Imhoff tank-trickling filter plant to serve a population of 55,000 is given in Table IV.

TABLE II.—ESTIMATED COST OF ACTIVATED SLUDGE PLANT.

	Cost excl. eng'g and administration. Total.	Unit cost, excl. eng'g and administration. Per capita.	Per M. G. D.
Grit chamber and screen	$ 10,000	$0.18	$ 1,818
Venturi meter and chamber	3,000	.05	546
Sewage aeration tanks	78,100	1.42	14,200
Slude aeration tanks, incl. air lifts	17,500	.32	3,180
Sedimentation tanks, incl. air lifts	8,300	.15	1,510
Air compressing equipment	22,600	.41	4,110
Air meters—2	700	.01	127
Air washer—1	600	.01	109
Power house	29,700	.54	5,400
Sludge beds, incl. underdrains	31,400	.57	5,710
Conduits, pipe lines and overflow	10,000	.18	1,818
Effluent drain	1,300	.02	236
Roadways	8,300	.15	1,510
Laboratory building and equipment	15,200	.28	2,760
Grounds, trees, planting, etc	1,700	.03	309
Miscellaneous work, 4% of total, excl. land	9,540	.17	1,735
Land	25,000	.45	4,540
Total	$272,940	$4.94	$49,618
Add 15% for eng'g and administration	40,940	.77	7,482
Grand total	$313,880	$5.71	$57,100

For 55,000 persons = $5.71 per capita.
For 5,500,000 gal. per day = $57,100 per m. g. d.

The estimated annual cost of operation of the activated sludge plant is shown in Table V. Nearly half of the annual operating cost is for electric power, required for compressing the air. It was estimated that in addition to the air required for sewage aeration one-fifth as much would be required for sludge re-aeration and for operating the air-lift pumps. The total annual cost of operation amounts to $40,140, which is equivalent to $20 per million gallons treated, or 73 ct. per capita, based on 55,000 persons.

The item for power is estimated on the assumption that it can be obtained at 1 ct. per kw. h. For many places this is a low price, while for others it is high. Surely it is low enough for use in computing the cost of power in most places upon a project which is to be operated for a generation in the future.

Comparison of Costs.

For the final comparison of costs the interest and depreciation have been computed for both plants, and the total annual cost, made up of operating expenses and interest and depreciation, has been capitalized at 4 per cent and added to the construction cost (Table XI). The result is decidedly in favor of the Imhoff tank-trickling filter plant, in spite of the fact that the estimates of operation of the activated sludge plant have been kept low, probably lower than is justified, that there might be no danger of inflating this cost to the disadvantage of the new process. To eliminate this difference it will be necessary to decrease the operating expenses of the activated sludge treatment by about $11,000, or to decrease them a portion of this amount and in addition thereto to decrease the construction cost materially.

TABLE III.—ESTIMATED ANNUAL COST OF OPERATION OF FITCHBURG, MASS., IMHOFF TANK-TRICKLING FILTER PLANT FOR THE YEAR 1916.

General, including administration	$ 1,800
Laboratory	1,700
Grit chamber	900
Imhoff tanks	1,700
Trickling filters	1,100
Secondary tanks	900
Sludge beds	800
Care of grounds	1,250
Miscellaneous	1,100
Total	$11,250

3 m. g. d. = 1,095 m. g. treated = $10.28 per m. g.
32,500 persons = $0.35 per capita.

A reduction in the price of power from 1 ct. to 6 ct. per kw. h., the price at which it is estimated power can be purchased at Milwaukee, would effect an annual saving of $6,816. For a plant only large enough for 55,000 persons it is doubtful if power below 1 ct. per kw. h. can be procured in many places.

It is not unlikely that improvements in the methods of diffusion and of holding the air for a longer time in contact with the sewage may result in a decrease in the quantity of air required. This would result in a decrease in cost.

TABLE IV.—ESTIMATED ANNUAL COST OF OPERATION OF TYPICAL IMHOFF TANK-TRICKLING FILTER PLANT.

General, including administration	$ 2,200
Laboratory	1,700
Grit chamber	1,650
Imhoff tanks	3,120
Trickling filters	2,020
Secondary tanks	1,650
Sludge beds	1,470
Care of grounds	1,250
Miscellaneous	2,020
Total	$17,080

5.5 m. g. d. = 2,005 m. g. treated = $8.50 per m. g.
55,000 persons = $0.31 per capita.

At the present time much attention is being given to methods of converting the sludge into marketable fertilizer. There is reasonable agreement among investigators that activated sludge contains a greater proportion of fertilizing ingredients than the sludges obtained from most other processes of sewage treatment. If the sludge can be converted into commercially dry powder containing only 10 per cent moisture, there is good evidence of a market for it at a moderate price.

TABLE V.—ESTIMATED ANNUAL COST OF OPERATION OF TYPICAL ACTIVATED SLUDGE PLANT.

Item		Annual cost.
General, including administration		$ 2,200
Laboratory		1,700
Grit chamber		1,650
Tank Treatment—		
1 engineer foreman at $4 per 8-hr. day, 312 days	$1,248	
3 engineers at $4	3,744	
4 laborers at $2.50	3,120	
Repairs	1,278	9,390
Sludge Drawing and Disposal—		
Foreman part time	$ 375	
2 laborers at $2.50, 312 days each	1,560	
1 team at $6, 312 days	1,872	
Supplies and repairs	603	4,410
Electric power at 1c per kw. h.		17,040
Care of grounds		1,250
Miscellaneous		2,500
Total		$40,140

5.5 m. g. d. = 2,005 m. g. treated = $20.00 per m. g.
55,000 persons = $0.73 per capita.

If the cost of preparation and sale of sludge should be no more than the return from such sales, the reduction in the foregoing estimates of operation and construction would be $5,030 and $66,000, respectively. If this process should be even more successful and a net profit of $2 per ton or say $1 per million gallons should be derived, the saving thus effected would amount to—

Profit on sludge	$2,007.50
Cost of sludge disposal as per previous estimate	5,030.00
Interest and depreciation on sludge beds	2,270.00
Total	$9,307.50

In addition to this annual saving there would be also the saving in investment cost of $36,000.

Even this profit and saving would not be enough to reduce the cost of the activated sludge process to that of the Imhoff tank-trickling filter process, but the net profit of $1 per million gallons may be substantially exceeded. In any event, this subject should receive, as indeed it is receiving, most careful investigation.

It may be argued that greater economy will be possible in the large plants than in the typical plant designed to serve 55,000 persons. This is undoubtedly true, but it is also true of the trickling filter plant. The proportionate saving in the cost of the activated sludge plant, however, may be somewhat greater.

TABLE VI.—COMPARISON OF COSTS OF IMHOFF TANK—TRICKLING FILTER PLANT AND ACTIVATED SLUDGE PLANT.

Item.	Trickling filter plant.	Activated sludge plant.
Operating expenses	$ 17,080	$ 40,140
Interest and depreciation*	26,760	19,780
Total annual cost of treatment	$ 43,840	$ 59,920
Total annual cost of operation per m. g.	21.84	29.85
Total annual cost of operation per capita	0.80	1.09
Expenses capitalized at 4%	$1,096,000	$1,498,000
Construction cost	431,710	313,880
Total	$1,527,710	$1,811,880
Difference		284,170

*Interest at 4%—Depreciation—Sinking fund at 2½%.

Further development, particularly in the direction of reducing the quantity of air required, and improving means of distribution, may result in a reduction of construction cost. It seems more probable, however, that the cost of construction will be increased, and in any event there should be no reduction in construction cost at a sacrifice in efficiency.

In spite of the fact that it appears to be somewhat more expensive than other processes, the activated sludge treatment should not be rejected on the ground of cost without giving full consideration to its advantages. It may be that as an oxidizing process it will always be more expensive than the trickling filter, but it may have advantages more important than this disadvantage.

Advantages and Disadvantages of the Two Processes. If it is assumed that the sludge from the activated sludge process is to be dried and disposed of by means of sludge beds, the total area of land used for the activated sludge plant will not differ greatly from that actully used for the trickling filter plant.

The areas utilized for several trickling filter plants, including a reasonable allowance for walks, drives and general purposes, are shown in Table VII.

TABLE VII.

Location of plant.	Area of land required for plant. Acres.	Area of trickling filters.	Average depth of stone in trickling filters.
Fitchburg, Mass.	11.8	2.07	10′ 3″
Schenectady, N. Y.*	19.0	6.1	4′ 7½″
Gloversville, N. Y.	13.5	3.07	4′ 7½″
Typical trickling filter plant, estimated	11.8	2.75	10′ 3″

*Original design; only one-half plant built.

The estimated area required for the typical activated sludge plant is 10 acres, or nearly 2 acres less than that required for the typical trickling filter plant. If some other form of sludge disposal were used, the area would be materially reduced. In the second annual report of the Milwaukee Sewerage Commission, it is stated that the ground area required for the Milwaukee activated sludge plant is 0.4 acre. This plant is capable of treating 1,620,000 gal. of sewage per day, but the area given makes no provision for sludge disposal and practically nothing for walks, drives and other features to be expected in an ordinary, complete plant. As already stated, the activated sludge plant may have some advantage in not requiring as much land for isolation as the trickling filter plant. The corresponding reduction in cost would be to the advantage of the former.

One of the important advantages of the activated sludge process is the small loss of head required for the passage of the sewage through the plant. The resulting saving in cost of sewerage works such as pumping stations and long outfall or intercepting sewers, may be sufficient to make the adoption of the activated sludge process imperative. The amount of head lost in several trickling filter plants is shown in Table VIII,

TABLE VIII.—HEAD LOST IN TRICKLING FILTER PLANTS.

Location of plant.	Head lost. Ft.
Columbus, O.	25.34
Fitchburg, Mass.	25.40*
Gloversville, N. Y.	21.40
Schenectady, N. Y. (original design)	13.79
Schenectady, N. Y. (actual construction)	14.65
Washington, Pa.	16.50
Philadelphia, Pa.	25.25
Atlanta, Ga., Peachtree Creek Works	20.00

*Actual is 42.1 due to topography.

From this table it will be seen that the head required for a trickling filter plant varies from 14 ft. to a little over 25 ft. The Milwaukee 1.62 m. g. plant requires 0.3 ft. between the inlet to the sewage aeration tanks and the outlet of the sedimentation tank. In addition to this some loss should be added for the grit chamber and screens, but in any event, a total loss of 1 to 2 ft. would appear to be ample.

There is some sentiment hostile to an Imhoff tank-trickling filter plant because of the fear of the dissemination of objectionable odors. That objectionable odors are noticeable in the immediate vicinity of such plants cannot be denied. On the other hand, there is good evidence that they are not noticeable except very close to the treatment plants.

The activated sludge plant appears to have some advantage in this direction. Odors may be noticeable in the immediate vicinity of the aeration tanks, and it is possible that objectionable odors may be given off from some portions of the sludge drying and handling process, whatever it may ultimately be. It is probable, however, that the danger from this source will be less than from the Imhoff tank-trickling filter plant.

The moth flies, so prevalent at certain seasons of the year, are quite objectionable close to the filters, although they are rarely found more than a few hundred feet away from them. While this cause of annoyance may be kept under reasonable control, it is doubtful if it can be wholly eliminated. The activated sludge plant does not seem to be a suitable breeding ground for these pests, and therefore has an advantage over the filter.

There is no doubt that the activated sludge process is capable of producing a more highly oxidized effluent than the trickling filter, as ordinarily built and operated, that it will eliminate a much greater proportion of bacteria, and that in appearance its effluent will be decidedly superior to that of the filter. This is a marked advantage under certain circumstances, but these facts alone should not be allowed to control in the adoption of a more expensive process when the accomplishments of the trickling filter answer all purposes.

A disadvantage of the activated sludge process in the minds of many who have studied it is its apparent complexity and need for careful and skillful supervision. While it has been contended by some that this process is exceedingly simple and one which can be operated by a workman of ordinary intelligence, the consensus of opinion appears to be to the contrary. The author's experience in operating several small experimental plants, leads him to feel that of all processes of sewage treatment in practical use in this country today this is by far the most difficult to operate and that it will require the skill of a well-trained engineer or chemist to insure continued satisfactory results with it.

At the present time it appears that the Imhoff tank-trickling filter process is a less expensive means of oxidizing the organic matter of sewage and industrial wastes than the activated sludge process, where oxidation alone is considered. If the areas of land required for isolation, the loss of head in the plant, the danger of objectionable odors and of the fly annoyance, and other disadvantages of the trickling filter process are of marked importance in any specific case the balance may be decidedly in favor of the activated sludge process, even in its present state of development.

METHODS AND COST OF BUILDING A CONCRETE SEWER, INVOLVING THE USE OF STEEL FORMS.

Although the facts in this article were gathered several years ago, they are nearly all applicable today. By allowing for the higher wages that are now paid, the unit labor costs under present wage rates can be derived.

The work relates to the building of a reinforced concrete sewer, 96 in. interior diameter, built by contract in an eastern city. The excavation was in sandy loam, not difficult to dig.

There was no pavement removed, for this was a section of the city having few residences.

The earth was loaded into buckets that were lifted by a derrick and dumped alongside or into Koppel cars, only such portion going into the cars as was used in backfilling. The derrick was mounted on the forward end of a platform that spanned the trench and ran on wheels. On the same platform, but at the rear, was another derrick used in handling buckets of concrete.

Water was encountered about 2 ft. above the bottom of the trench, and two Pulsometer pumps were usually kept busy handling this water. The pumps received their steam from the boiler that supplied the hoisting engines.

The following was the organization of the gang engaged in building the sewer:

	Per day.
1 superintendent at $6	$ 6.00
1 engineman at $3.50	3.50
1 hoister (one engine) at $2	2.00
2 tagmen at $1.65	3.30
10 men excavating earth at $1.65	16.50
2 men on dump cars at $1.65	3.30
1 bracer (carpenter on bracing) at $3	3.00
2 bracer's helpers at $1.65	3.30
2 men laying bottom planks at $1.65	3.30
and moving pumps, etc., at $1.65	3.30
3 men pulling sheeting at $1.75	5.25
16 men mixing and placing concrete at $1.65	26.40
3 men on forms at $1.75	5.25
1 water boy at $1	1.00
Total	$85.40

Coal and oil cost about $5 per working day of 10 hours.

During half a year the actual field cost of the labor on this sewer was $7.86 per lin. ft., distributed as follows:

	Per lin. ft.
Excavation	$1.80
Placing sheeting and bracing	0.58
Placing bottom plank	0.17
Pulling sheeting	0.45
Backfilling	0.33
Making and placing concrete invert	1.17
Making and placing concrete arch	1.54
Laying brick in invert	0.29
Bending and placing reinforcing steel in arch	0.20
Bending and placing reinforcing steel in invert	0.09
Placing and moving forms and centers	0.62
Watchmen, waterboy, etc.	0.62
Total	$7.86

The excavated section of the trench was 12½ ft. wide and varied somewhat in depth. When it was 12 ft. deep, the cost was $1.61 per lin. ft., which was a trifle less than 30 ct. per cu. yd. for all labor, excepting the labor of backfilling. When the trench excavation averaged 5.56 cu. yd. per lin. ft., the backfill averaged only 1.7 cu. yd. per lin. ft. and this backfilling was done at a cost of about 20 ct. per cu. yd. of backfill. The backfill was not rammed.

The trench sheeting consisted of 4-in. plank, which was subsequently used as a floor or bottom upon which the concrete invert was laid. This plank floor consisted of two layers of plank, giving a thickness of 8 in.

The sheeting was braced with 6x6-in. braces, three of which were used to each 16 ft. length of wale. There were two lines of 4x6-in. wales. Hence the trench required about 120 ft. B. M. of sheeting and bracing per lineal foot of trench. Since it cost $0.58 per lin. ft. of trench to place this timber, this is equivalent to $4.80 per 1,000 ft. B. M.

The pulling of the sheeting cost $0.17 per lin. ft. of trench, which is equivalent to about $1.50 per 1,000 ft. B. M. of timber removed. The pulling was done with a light tripod on which was mounted a winch operated by two men. A small wire rope from this winch passed over a pulley at the top of the tripod and was fastened to the sheet pile to be pulled. Two legs of the tripod rested on the ground and the third was supported by a plank resting on the bracing over the center of the trench. There were three men in the gang pulling the sheeting.

The concrete was a 1:2:4 mixture, and about 1¼ bbl. of Portland cement were used per cubic yard. Gravel was used for the aggregate. The invert contained 0.8 cu. yd. of concrete per lin ft., and the arch contained 1.4 cu. yd. per lin. ft., or a total of 2.2 cu. yd. The mixing was all done by hand. The concrete for the invert was shoveled into dump buckets and lowered to place by the derrick above mentioned. The concrete for the arch was delivered in two wheel dump carts pushed by hand.

Referring to the tabulated labor costs given above, we see that making and placing concrete in the invert cost $1.17 per lin. ft., which is equivalent to nearly $1.20 per cu. yd. of concrete invert. The corresponding cost for the arch was $1.54 per lin. ft., which is equivalent to $1.10 per cu. yd. of arch. The combined cost was $2.71 per lin. ft., which is equivalent to $1.23 per cu. yd. of concrete in the sewer.

The greater cost of placing concrete in the invert was due partly to the presence of the reinforcing rods, which interfere with placing the concrete quickly. The labor of the men on the tag ropes swinging the derrick boom, as well as the labor of the derrick hoister, ran up the cost, particularly as the daily output of concrete was low. A bull wheel on the derrick would have eliminated the men on the tag ropes.

Bending and placing the twisted steel reinforcing rods cost $0.29 per lin. ft. of sewer (invert and arch combined); and, as there were 366 lb. of this reinforcement per lin. ft. of sewer, the labor cost was 0.8 ct. per lb. The cost was frequently as low as 0.6 per lb.

The concrete invert was lined with common bricks set on edge, there being about 40 bricks per lin. ft. of sewer. A brick mason was paid 15 ct. per lin. ft. for laying the bricks, and, in addition to this, the cost of labor mixing and delivering mortar, etc., amounted to 14 ct. per lin. ft., making a total of 29 ct. per lin. ft. of sewer

We come now to the forms and centers. The cost of labor for placing and moving forms for the invert averaged 9 ct. per lin. ft., and the corresponding cost for the arch averaged 53 ct., making a total of 62 ct. as above given. Later on these costs were reduced to 5 ct. and 46 ct., respectively, making a total cost of 51 ct. per lin. ft. of sewer. At 51 ct. per lin. ft., the labor cost on the forms and centers was only 23 ct. per cu. yd. of concrete, which is a remarkably low record. How this low record has been attained should interest every sewer contractor.

Let us now estimate the cost of a 96-in. reinforced concrete sewer, giving the costs in terms of the cubic yard of 1:2:4 concrete as the unit:

	Per cu. yd.
1.25 bbl. cement at $1.50	$1.88
0.42 cu. yd. sand at $1.25	0.53
0.84 cu. yd. gravel at $1.25	1.05
166 lb. reinforcing steel at 2 ct.	3.32
Labor mixing and placing concrete	1.23
Labor on forms	0.23
Labor on reinforcing steel	0.13
General expense	0.30
Total	$8.67

If these figures are multiplied by 2.2, the cost per lin. ft. of concrete sewer is obtained. These costs do not include the rental paid for the use of the Blaw steel forms and centers. Since the concrete could be as cheaply placed without the use of a derrick as with it, no allowance is made for the interest, depreciation and repairs of the derrick plant.

It will be noted that the design called for a much larger amount of reinforcing steel than is commonly used in sewers of this size.

DEVELOPING A SUPPLY BY TAPPING WATER-BEARING STRATA WITH TILE PIPE LINES.

Contributed by L. U. Martin.

Last spring the city of Glenwood, Minn., becoming alarmed over the small amount of water on hand in its storage tank for fire purposes, determined to see what could be done to increase the supply. Several years before the city had voted bonds for this purpose to the extent of several thousand dollars with the idea of buying another spring and building storage tanks and pipe lines to connect with the present mains. Owing to litigation which followed over the water rights this plan had been abandoned. To add to the difficulties the State Board of Health upon inspection of the plant had condemned it as being very unsanitary and sent back a report showing a rather dangerous amount of bacteria in the water. Two things must be done: increase the water supply and also make the conditions of collection sanitary.

Acting upon request of the city council the writer began an investigation as to the best and cheapest method of procedure. Upon looking over the ground he found that the water was obtained from a series of springs along the side and apparently the bottom of a narrow ravine in the hills surrounding the city. The country was covered to a depth of many hundreds of feet with glacial drift, and these hills were of clay and gravel. The city lay at the foot of these hills along the short of a large lake. The ravine was about 400 ft. long, 275 ft. wide at its lower end and narrowed down at its upper end to a few feet where it ascended sharply to the plain above. The bottom of the ravine from the lower to upper end was on about a 5 per cent grade and was covered with a mixture of boulders, clay, gravel and decaying logs. At the lower end of this ravine a dam had been built of logs and rock to prevent erosion during heavy rains. About 100 ft. above this dam a concrete storage tank, elliptical in shape, 28 ft. by 96 ft. on its axis, and from 13 ft. at its lower end to 10 ft. at its upper end in depth, and covered with a corrugated iron roof, had been built. Above this tank was a weir house and a two-compartment open settling basin. The water from the ravine was collected in the settling basin, flowed from there to the weir house and thence through a 6-in. iron pipe to the storage tank. The tank was at an average elevation of 150 ft. above the city.

The tank was about 15 ft. below the settling basin and weir house in elevation. Opposite the tank were two more springs, which had been inclosed in concrete houses and which sent their water directly through 2-in. pipes to the tank. The grounds though inclosed by a woven wire fence were open to the public and were a favorite place for picnics. Children were even allowed to play in the stream, and picnic refuse was scattered around. The grounds were at once ordered closed to the public and no-trespass signs posted.

The next step was to determine the extent and formation of the spring basins. Upon taking levels it became apparent that the spring basins along the side of the ravine were at the same elevation except the uppermost spring which was about 6 ft. above the rest. Further investigation showed that this line of elevation was marked by a distinct strata of blue clay, above which lay a water-bearing strata of gravel and sand of about 6-ft. thickness, which accounted for the spring at the upper end of the ravine being at a higher elevation. Here the sand had not been washed away and the water came out at the top of the sand instead of along the line of the blue clay. It was then apparent that no water was coming up through the bottom of the ravine, but that the water was seepage water flowing through the accumulated wash from the sand strata above. Further study and levels, which, owing to the vegetation and wash material, made it necessary to put down several test pits, brought out the following facts: A heavy capping of yellow clay covered the entire area and extended back over the plain behind, where it thinned out to a few feet in thickness. This capping directly over the spring area was from 20 to 30 ft. in thickness and acted as a dam holding back the water in the strata under it, which strata was a layer of course sand and gravel from 4 to 6 ft. in thickness. Below this water-bearing strata was an impervious layer of blue clay of undetermined thickness, underlain again by another water-bearing sand strata.

Investigation showed that the lower spring level was so far below the upper one that it was out of the question as a source of water unless pumping was resorted to and this we wished to avoid. The next thing to be considered was whether enough water could be developed in this ravine to supply our needs. It was plain that by the removal of the wash clay from over the spring line that the springs would flow more freely and give more water. It was then necessary to see if by so doing we would exhaust our water supply and have a period of low flowage later To determine this question it was necessary to study the country on the plain back of the ravine whence it was apparent the water came and to ascertain what other sources of outlet it had. Numerous other ravines were found which cut the water basin, and, while one or two contained streams of considerable size, they were for the most part undeveloped and covered with wash material which held back the flow of water. The plain itself extended for several miles east, north and northwest of the ravine and was nearly all gravel covered in places with a few feet of clay or loam. The thickness of the gravel strata determined from records of wells drilled and dug in the plain was 50 ft. at all points. It contained several lakes of considerable size and many pug holes which seemed to have a blue clay underlaying strata. From these surface indications, the elevation of the lakes, the direction of flow of their outlets, and the sameness of the material, it was decided that the springs were connected by sand strata with the lakes. This gave us reason to believe our water supply could be developed without danger of later diminution. Accordingly we made the following recommendations to the city council:

That a line of 12-in. vitrified tile be laid up the bottom of the ravine from the weir house below the wash material with 8-in. branches every 25 ft. on each side. These branches were to terminate in right angle branches along the spring line. By so doing we not only expected to increase the flow of water but also to meet the sanitary conditions imposed by the State Board of Health, and do away with the unsanitary, troublesome settling basins. After every heavy rain these basins had to be cleaned of accumulated mud. Our plan called for 250 ft. of 12-in. plain vitrified tile, 20 12-in. Y branches with 8-in. reducers, 1,000 ft. of 8-in. vitrified tile, and cement and brick enough for joints and manholes.

It was recommended that the work be done by day labor owing to the uncertain condition of the material to work in and the smallness of the job. The tile in all cases was to be laid on a bottom of blue clay and carefully covered with clean washed gravel. The total estimated cost was from $500 to $600. The council after hearing the report, and especially the estimated cost, at once voted the authority to proceed.

The work was begun with two expert tilers and these were later furnished with from one to three ordinary helpers when needed. Tile was ordered and hauled by the city. Upon advice of the Board of Health it was deemed advisable to treat the water while the work was in progress so that all chances of contamination would be avoided. This was done by a very simple and inexpensive device at a very small cost.

An ordinary vinegar barrel with a wooden spout was arranged on a stand over the stream as it entered the settling basin. Into this was placed a determined amount of $CaCl_2$, depending on the flow of water, and the barrel filled with water. The spout was then opened a sufficient amount so that the barrel was emptied every eight hours. At first all water above the men at work was by-passed around them and into the settling basin. In this way they had no cause to come into contact with it. As the water flowed through the settling basin the chlorine became thoroughly mixed with it. As the water supply was low and no other supply available we did not try to crowd the improvement, but put only two men at work so that enough water could be by-passed to keep the city supplied.

It was figured that as the ground was opened up more water would be developed and later the water from the lower end used and that from the upper end wasted while the men were working in it. The main tile was first laid clear to the end, the Y's being inserted at the direction of the writer, for after opening up the ground it was decided to take advantage of the ground conditions rather than to try to place them at regular intervals. The water on both sides of the main line was toward the end led around in ditches and into the settling basin for use while that which came through the tile was wasted. As the upper end was neared it became more difficult to reach the clay bottom owing to the inwash of gravel and sand from the sides. Toward the end piling became necessary to hold this back. When the upper end was reached a manhole of brick and cement was built. The flowage from the last 50 ft. alone became as great as we were getting before the work started.

The last 50 ft. having been laid through, or rather under, the sand strata the water soon found its way into the tile. The main was now covered with clean gravel from 4 to 6 ft. deep and the water sent directly into the weir house. Excavation for the branches was then began. One branch was taken at a time and completed. They were not connected to the main until completed, the water up to that time being wasted. Nineteen branches were built in all, from 2 to 58 ft. in length. At the end of each branch it was found both unnecessary and inadvisable to lay a right angle line as planned originally, as a manhole collected the water as well and the cost of working against the bank pressure was too great. A manhole about 2 ft. in diameter of brick and cement or in some cases cobblestones was made at the end of each branch.

When a little over half of the branches had been completed a severe fire started in the city. The men hearing the alarm turned in all the available water, and during the time of the fire the water level in the tank did not lower to any appreciable extent.

When the work was completed the ravine became so dry that a team and wagon were driven up it and all old logs cleaned up and removed.

The tank was now emptied and cleaned. Owing to the open settling basins it was covered on the bottom with several feet of mud, and the frogs present would have filled several bushel baskets. When the water was again turned on, the tank which contains 160,000 gal. was filled in about eight hours and has ever since had an overflow sufficient to supply the city should it grow to three times its present size. As there are absolutely no operating expenses the water revenue is a considerable source of income to the city and the cost to the public very slight.

The whole cost can be summed up briefly as follows:

Labor, $300; tile and other material, $250; other expenses incidental to treating the water, engineering services, notices, etc., $75.

A machine for applying a protective coating of zinc on other metals by a process of hot spraying was received at Gatun Locks of the Panama Canal during January, under lease from the manufacturers. Experiments were begun by coating sample pieces of different metals and immersing them in sea water in order to observe to what extent they will be protected. It is hoped that the process may prove effective for protecting immersed valve parts against electrolytic action and other forms of corrosion.

During the calendar year 1916 the Panama Canal was transited by 1,253 oceangoing vessels. Their aggregate net tonnage, according to the rules for measurement for the canal, was 3,933,869 tons. The total amount of cargo carried through the canal in the year was 4,931,911 tons of 2,240 pounds. The gross tonnage of the ships, according to the rules for measurement for the canal, was 5,574,661.

THE OVERHEAD IRRIGATION SYSTEM OF THE R. M. KELLOGG CO., THREE RIVERS, MICH.

Overhead irrigation has come into extensive use in the last few years. In many cases the system covers only a small acreage, but in at least three instances, tracts each of over 100 acres are irrigated in this way. The second largest overhead irrigation system in this country, and one of the most interesting, is that of the R. M. Kellogg Co. at Three Rivers, Mich. This company specializes on strawberry plants and cantaloupes and is said to have the largest strawberry plantation in the world. At the present time it is irrigating 120 acres of the plantation by the Skinner overhead system. The first unit, covering 65 acres, was installed about two years ago. In this unit alone there are 25 miles of overhead piping. A second unit of 55 acres was added in 1915.

The layout of the irrigation system at Three Rivers is shown in Fig. 1. The water is taken from the Portage River which borders one side of the farm. The intake is 10 in. in diameter and about 15 ft. in length and is covered with a screen, placed horizontally in the stream from 2 to 3 ft. below the surface and from 1 to 2 ft. above the river bed.

The pump supplying the system is an "American" 8-in., Type D T M D, horizontal, single stage, double suction, split shell turbine centrifugal, designed for a normal delivery of 1,050 gal. per minute against 176 ft. total head. It is driven by a 75-H. P., 3-phase, 60-cycle, 220-volt, slip ring, General Electric motor operating at 1,740 r.p.m. The electricity is obtained from the local municipal electric plant. The pumping installation is housed in a concrete building on the bank of the river.

The pump discharges through a 10-in. pipe, which reduces to 8 in. within a short distance. A globe valve is placed at the point of reduction. The main field pipe leads underground to the upper end of the farm where it divides into laterals leading to various sections of the overhead system. All underground pipe is of cast iron standard bell and spigot type, ranging from 10 in. down to 4 in. in diameter.

At intervals of approximately every 52 ft. along the feeder lines risers, consisting of 2½-in. galvanized pipe, are inserted. These rise perpendicularly from 7 to 10 ft. above the ground level. The upper end of each riser is fitted with a tee from which extend the nozzle lines at right angles to the feeder line. Close to the risers each nozzle line is fitted with a globe valve, handle and union containing a cone-shaped brass screen placed at the apex toward the riser. This screen prevents silt or sand which might pass through the strainer located at the source of the water supply from getting into the nozzle lines. The nozzle lines range in diameter from 2 in. down to ¾ in., the decrease being for the purpose of maintaining a uniform pressure at all points in the system.

The spraying nozzles are inserted every 3 ft. along the nozzle line in a uniformly straight line, their streams forming a theoretical plane. The nozzle lines are supported every 15 ft. by 1¼-in. pipe sunk into the ground from 3 to 5 ft. and rising above the ground from 7 to 10 ft. The upper end of each pipe support is fitted with a hanger containing three brass rollers, so arranged that the nozzle line rests on each of these rollers and may be easily turned by means of the handle which is attached to the line close to the riser.

The nozzle lines can be turned through the entire 360 degrees, making it possible to set the nozzles at any desired angle, which in turn makes it possible to irrigate any portion of the area reached by the stream of the nozzle lines.

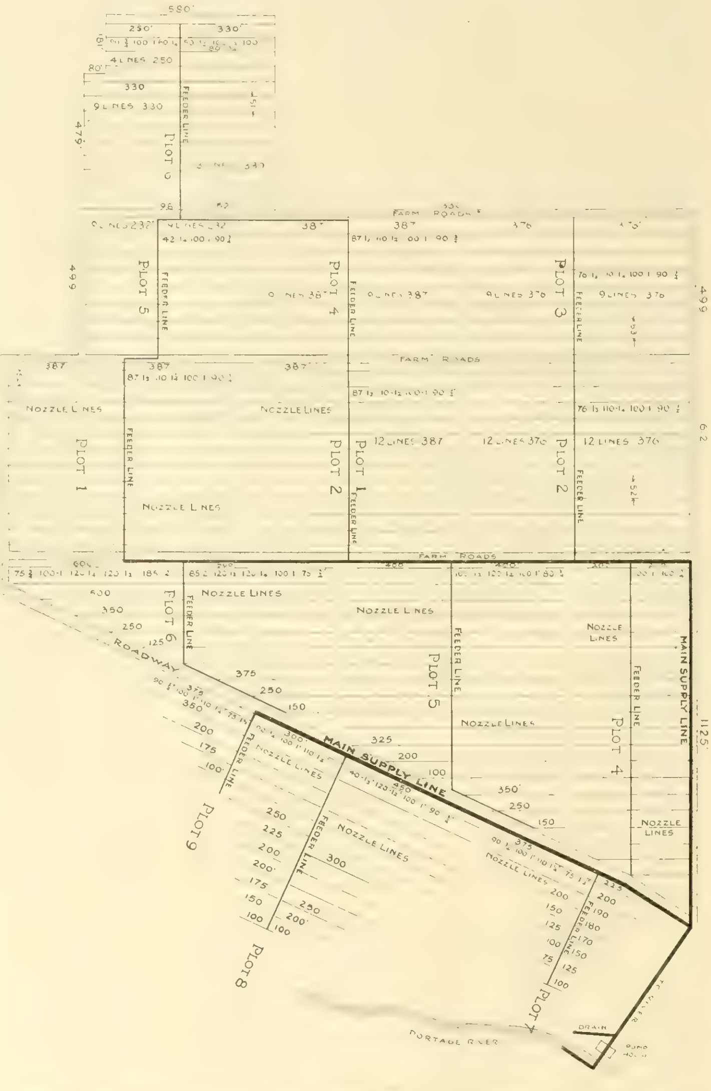


Fig. 1—Layout of Underground and Overhead Piping of Kellogg Irrigation System.

The nozzle lines have a carrying capacity of 26 ft. on either side of the line. The extreme end of each nozzle line is fitted with a drain cock for draining and flushing purposes.

By means of underground gate valves and the globe valves on the nozzle lines, it is possible to turn on or off any desired portion of this system.

When irrigating a practically uniform pressure of 75 lb. per square inch is maintained. The Kellogg Co. irrigates approximately 22 acres at a time. About 60 gal. per minute are required for one acre, and the total time required to saturate the entire 22 acres is about 4 hours. One man is stationed in the power plant and two men are stationed in the fields for the purpose of changing the position of the lines and cleaning nozzles which occasionally become clogged. The Three Rivers plant cost about $30,000, or $250 per acre.

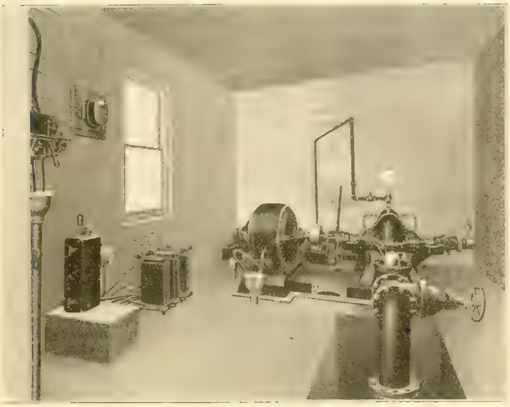


Fig. 2—Interior of Pumping Station.

STANDARDS OF MECHANICAL FILTRATION PLANT PERFORMANCE.

Empirical standards for bacterial count and for allowable frequency of bacilli coli in mechanical filtration plant operation are suggested by Mr. Abel Wolman, Resident Engineer, Northern District, Maryland State Department of Health, in a paper in the American Journal of Public Health. The suggested standards are the result of a study of the operation of filtration plants in Maryland. Mr. Wolman's paper, in part, follows:

A more accurate measure of bacterial removal is one in which the increases in absolute numbers are modified by the substitution of data that vary with these numbers but do not increase with the same rapidity. It is a well-known fact that the logarithms of numbers fulfill this requirement, since they do not increase as rapidly as do the numbers themselves. The substitution of logarithms for the numbers of raw water and effluent bacteria and the calculation of these logarithms should for these reasons give a more satisfactory measure than that now in use. To illustrate:

Plant A—Raw water = 5,000; effluent = 50; efficiency = 99 per cent.

Plant B—Raw water = 50,000; effluent = 500; efficiency 99 per cent.

In Plant A the logarithm of 5,000 is equal to 3.7, while that of 50 equals 1.7. Taking the ratio of these two, we have a value of 2.2. In Plant B the logarithm of 50,000 equals 4.7; of 500, 2.7. The ratio of these is 2.7. It is evident from this relation that Plant B is not performing as efficiently as Plant A. The old measure of efficiency of both, 99, shows no such conclusion. It is the writer's purpose, therefore, to illustrate the application of the above method in calculating efficiencies of a number of plants throughout the country, and then to make use of the same in the subsequent discussion. For the sake of clearness he will hereafter refer to the above ratio of logarithms of raw water and effluent counts as the "coefficient of efficiency."

In order to obtain sufficient data for a study of filtration plant performance operating results were obtained from various plants throughout the country. In Tables I and II the results obtained have been classified. Table I gives the bacterial counts of raw water, filtered and disinfected effluents. Table II contains a tabulation of the coefficients of efficiency under varying conditions of counts. For purposes of discussion the coefficients of efficiency, based on mean counts at 20° C., will be used, since most of the plants have apparently used these counts. As is noted on the heading of Table II, these coefficients have been calculated upon the basis of raw water and final effluent, whether disinfected or not, so as to represent a measure of efficiency of the entire plant. The application of the coefficient can, of course, be extended to the measurement of individual phases of operation within the plant itself.

TABLE I.—STATISTICS OF OPERATION OF VARIOUS RAPID SAND FILTRATION PLANTS.

Bacterial count.

Raw water				Plant effluent			
20 per cent.		37 per cent.		20 per cent.		37 per cent.	
Mean.	Max.	Mean.	Max.	Mean.	Max.	Mean.	Max.
....	....	156	1,280	..	....	6	500
2,122	32,000	..	....	7	22	..	...
2,051	38,000	.	.....	5	20	..	...
2,968	9,600	..	.....	41	101	..	...
16,500	100,000+	....	..	36	250+	.	...
...	.....	400	10,000	..	.....	0	...
...	......	7	......	.	.....	7	..
8,027	100,000+	..	...	24	250	.	..
6,951	118,000	.	.	39	430	..	...
.	....	1,332	7,300	..	.....	3	17
12,460	130,000	1,600	15,900	12	2,080	11	520
350	70,000	....	.....	6	43	..	...
...	...	77	1,100	.	....	2	30
3,451	15,500	...	....	24	84	..	...
1,811	40,250	121	.....	3	60	1	..
2,868	21,500	....	...	19	520	.	
2,517	22,500	.....	....	17	435	..	...
.....	.....	1,714	2,600	.	....	7	160
.	....	800	7,000	..	.....	4	10
....	....	3,894*	......	.	.....	18	...
1,575	74,200	.....	....	6	150	..	...
9,284	260,000	.....	.....	30	290	..	...
1,700	6,900	.....	......	5	30	..	...
.....	.....	724	2,631	..	....	19	89
10,541	75,000	.....	......	34	900	..	...
47,189	330,000	.....	.....	289	4,800	..	...

*Not under laboratory control. †No record.

After making an examination of the data tabulated in the above tables it becomes clear what standard of efficiency may be reasonably demanded of mechanical filtration plants. This standard is suggested in the following:

No mechanical filtration plant should be considered as operating efficiently unless a coefficient of efficiency of at least 2.5 (based on mean counts of raw water and final effluent at 20° C.) is consistently obtained. This, of course, is modified by the following:

As a corollary to this it should be stated that a plant

Fig. 3—Small Part of the Overhead System.

TABLE II.—STATISTICS OF OPERATION OF VARIOUS RAPID SAND FILTRATION PLANTS

Coefficient of efficiency—raw to final effluent.

Mean count—20°.	Mean count—37°.
....	2.81
3.92	....
4.73	....
2.17	....
2.71	....
....	*
†	†
[illegible]	....
[illegible]	....
....	[illegible]
[illegible]	[illegible]
[illegible]	....
....	[illegible]
2.56	....
6.80	*
2.70	....
[illegible]	....
	[illegible]
....	[illegible]
	[illegible]
4.10	....
2.68	....
[illegible]	....
	[illegible]
2.61	....
1.90	.

*Infinity—Effluent [illegible] 0, hence log. = 0; therefore coefficient = [illegible] obtaining on an average less than 2.5 is either working inefficiently or else the bacterial content of the raw water is comparatively low.

Let us now test these requirements by an example: If a raw water contains 100,000 bacteria per cc., the effluent must contain no more than 100 per cc., in order to maintain a coefficient of efficiency of 2.5. If the raw water should contain 1,005 per cc. and the effluent 16, or the raw water 500 and the effluent 12, the coefficient would still be 2.5. However, if the bacterial counts were 100 and 10, for the raw and filtered water, respectively, the coefficient of efficiency would be only 2.0. But in this case the bacterial count in the untreated water is low and, considered from this one point of view alone filtration is not needed.

That the filtration plants of this country should meet this requirement, except under extraordinary conditions, is indicated by the fact that almost all of those of which the writer has record can and do meet it. Within the limit of raw water count suggested above, a coefficient of 2.5 does not seem to be too high. So far as the writer is aware, no mechanical filtration plant for a public water supply has to deal with water averaging anywhere near 100,000 bacteria per cc.

It should also be noted that any coefficient below 1.0 would indicate that the plant is producing an effluent worse in bacterial content than the raw water.

One advantage of the coefficient of efficiency evidently lies in the fact that it is not as much influenced by great numerical increases in bacteria as is the percentage removal measure, based on actual counts. A far more important advantage, too, is that the influence of great increases in counts in effluent samples is greater than those in raw water samples since the logarithms of small numbers increase more rapidly than those of large. This should be so, since, in the past, no mathematical cognizance of sufficient weight has been taken of the filter effluent count—which after all is of prime importance in estimating the operating efficiency of the works. This comparison of coefficients of efficiency and actual percentage removal is well illustrated in the following table of results of a plant in Maryland (Table III).

The month of December, 1915, for instance, shows a percentage efficiency greater than that of November. The average effluent count is, however, higher. The coefficient of efficiency, on the other hand, gives a more accurate picture of the work of the plant from the point of view of the sanitarian, since November shows a higher coefficient than December. It is interesting to note, also, that practically each month this plant showed a removal of over 99 per cent, even though the effluents varied in count from 4 to 592 per cc. It is plainly obvious from the above table that the coefficient of efficiency follows more sensitively than the percentage removal the true performance of the works.

Together with a standard for bacterial counts, there must be also at hand some standard to determine the allowable frequency of bacilli coli in the plant effluent. In determining this standard, the same method as used above was followed; that is, an empirical rather than arbitrary standard was sought. Presumptive, rather than isolation, tests were used, because most of the plants, for which records are available, do not attempt to isolate and because, for purposes of comparison only, it is unimportant whether the isolations are a low or high percentage of presumptives. This is particularly true, since similar conditions are being compared and any error which would occur would affect the results of each plant in the same way. Practically all of the plants used hypochlorite or liquid chlorine. The academic question as to whether B. coli are actually isolated in any one plant is important for any absolute guarantee of the purity of the effluent, but in a measure of the operation of a plant a comparative standard is for practical purposes sufficient. Such a standard based upon presumptive tests only is, therefore, warranted. An examination of Table IV indicates that the range of coli in 1 cc., in raw waters at various plants, varies from 60 per cent to 100 per cent of all samples. A further study of this same table discloses the fact that a majority of the plants listed can obtain an effluent showing colon present by presumptive test in 10 cc. in less than 10 per cent and in 1 cc. in not more than 2 per cent of the samples. A number of the plants obtain much better results than these. The above data show fairly well that there is a degree of uniformity in the presence of colon in the raw water of all plants.

TABLE III.—COMPARISON OF COEFFICIENTS OF EFFICIENCY WITH PERCENTAGE REMOVAL OF BACTERIA ON THE BASIS OF AVERAGE COUNTS AT 20° C.

1915.	Coefficient of efficiency.	Percentage removal efficiency.
October		
Raw—10,842		
Eff. — 48	2.39	99.557
November		
Raw— 1,009		
Eff. — 4	5.00	99.604
December		
Raw—19,771		
Eff. — 52	2.50	99.737
1916.		
January		
Raw—33,150		
Eff. — 198	1.97	99.403
February		
Raw—64,100		
Eff. — 136	2.26	99.788
March		
Raw—80,368		
Eff. — 592	1.77	99.263
April		
Raw—55,056		
Eff. — 196	2.07	99.644
May		
Raw— 3,270		
Eff. — 25	5.40	99.061
October 1—December 31, 1915, and January 1—May 31, 1916.		
1915.		
Raw—10,541		
Eff. 34	2.61	99.677
1916.		
Raw—47,189		
Eff. — 289	1.90	99.388

As a measure of the efficiency of the plant, from the point of view of colon removal, the following standard is suggested:

That the percentage of samples showing colon present in the effluent of a mechanical filtration plant by presumptive tests shall not exceed 10 per cent in 10 cc., nor 2 per cent in 1 cc.

In interpreting daily B. coli results at any plant, it has been found, too, that no satisfactory measure exists to determine the relative efficiencies of colon removal of various stages of operation. If a raw water containing B. coli in 0.01 cc. passed through the coagulating basin and entered the filter beds with colon present in 0.1 cc. and finally left the filters with colon in only 1 cc., we had no measure of the changes taking place, so as to compare individual stages of operation on successive days. The method of Phelps, of using the reciprocal of the greatest dilution giving a positive test as the actual num-

TABLE IV.—STATISTICS OF OPERATION OF VARIOUS RAPID SAND FILTRATION PLANTS.

Colon bacillus—per cent of test positive.

Raw water								Plant effluent			
Presumptive				Isolation				Presumptive.		Isolation.	
10.	1.	0.1	0.01.	10.	1.	0.1.	0.01.	10.	1.	10.	1.
100	100							0	0		
	64*								0.54*		
	87.5								1.88		
	90	46.4	10.6						1.08		
91	77							0	0		
								7.4	0		
	88.8	63.9	6.0					22.7	6.27		
						‖					
100	91							17.0	0		
		87.0						26.3	3.20		
	90.2	45.3			81.0	37.0		7.7	0.50	6.0	0.20
86.8								0.27			
	48.9								1.22		
	30.8								0.64		
	23.8								0.21		
	92.0							4.0			
99	85.0							†		†	
	‡99.1	78.0						30.5	6.40		
	36.3								0		
100	87.6							3.09	0		
					86.0					3.4	0
	§98.0									16.4	4.3
100	91.0	46.0	16.6	69.0	54.0	30.3	7.1	50.0	2.0	4.0	2.0
100	72.0	32.0	12.6	76.2	50.4	22.2	7.2	68.6	10.6	15.2	5.8

*Average for 7½ years. †Less than 1.00. ‡Not under laboratory control. §In 0.5 cc. ‖No record.

ber of B. coli present, is of value in determining the absolute quality of effluents at various stages, but for comparisons within the plant it has objections which the writer will attempt to make clear. Using the example quoted above, we have the following, by Phelps' method: Raw water = 100 B. coli per cc., coag. basin effluent = 10 per cc., filter effluent = per cc. By the percentage method the removals are as follows: Coag. basin = 90 per cent., filter effluent = 90 per cent; total plant = 99 per cent. If on the second day the raw water conditions were the same and the filter effluent showed B. coli in 10 cc., the efficiency of the entire plant would be 99.9 per cent. The percentage method, in other words, places too great emphasis upon low degrees of colon removal. The measure which the writer will venture to suggest, has for its object the comparison of the successive steps of colon removal, rather than of actual quantities of B. coli. For this purpose a "Standard Hygienic Efficiency" has been arbitrarily assumed as 100 per cent when there are removed from a raw water showing positive presumptive or isolation tests for colon in 0.01 cc. sufficient bacilli to produce an effluent showing negative presumptive or isolation tests, as the case may be, in 100 cc. The following table has been devised for uses as above outlined:

Colon present in			
Raw water +	0.01		100% standard hygienic efficiency, when raw water is positive in 0.01 and effluent is negative in 100 cc. Each intermediate step = 20% S. H. E.
		20%	
+	0.1		
		20%	
	1.0		
		20%	
+	10		
		20%	
+	100		
		20%	
Plant eff. —	100		

By the percentage method, using Phelps' system, this table would be:

Raw water +	0.01		100% (minus).
		90%	
+	0.1		
		90%	
+	1.0		
		90%	
+	10		
		90%	
+	100		
		90%	
Plant eff. —	100		

That is, less than 10 per cent absolute difference exists between any one step in this process and the entire process. Inasmuch as it is not yet established just what relative difficulty of filtration is encountered in each step, it is only fair to assume an equal efficiency for each successive step of colon removal.

(1) Raw water = B. coli in 0.1 cc.
Plant effluent = B. coli in 100 cc.
Standard hygienic efficiency = 60%.
Efficiency by Phelps method = 99.9%.
(2) Raw water = B. coli in 0.01 cc.
Plant effluent = B. coli in 100 cc.
Standard hygienic efficiency = 80%.
Efficiency by Phelps method = 99.99%.

The writer wishes to reiterate here that the "Standard Hygienic Efficiency" is of use only in the interpretation of data within the plant or in comparison with other plants and not as a measure of the sanitary quality of the effluent. For the latter purpose, the judicious use of the coefficient of efficiency combined with Phelps' method of estimating B. coli gives all that is desired within practical limits.

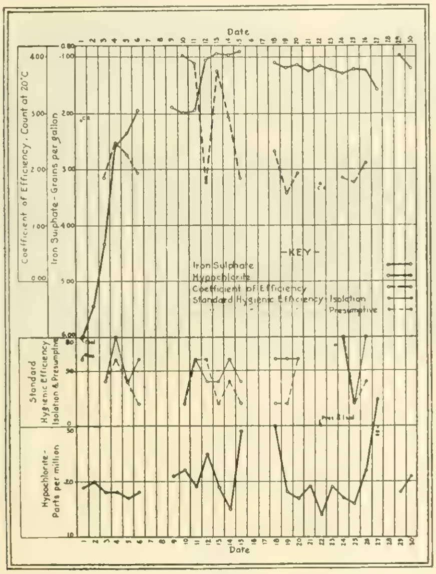


Fig. 1.

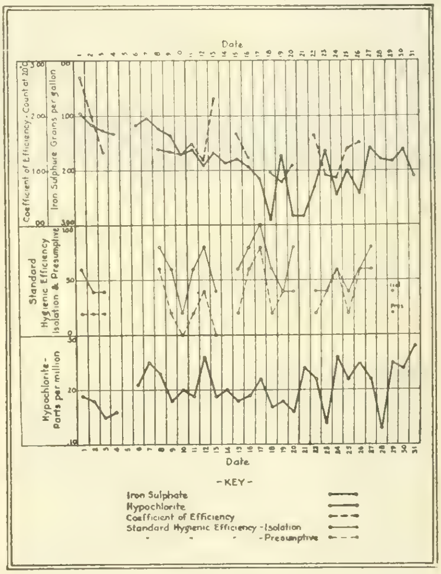


Fig. 2.

The application of the S. H. E. to the solution of practical problems in filtration is illustrated in Figs. 1 and 2. Here comparisons are made, for successive days, between S. H. E. coefficients of efficiency, and various doses of a plant in Maryland. The advantage of the measures used over the former percentage methods is clear when it is realized that, by the old system, almost all the total removals would be in the neighborhood of 99 per cent, and most of the colon removals indistinguishable from one another.

Preventing Water Tanks Freezing.—General stock raisers and dairy men at Goshen, Ind., according to the Electrical World, have overcome the trouble they have experienced in cold weather with water tanks freezing by operating the pumps used in raising the water from wells just fast enough so that the warmer water of the supply source will maintain the water in the tanks at a temperature above freezing. Enough water is allowed to discharge from the bottom of the tank where the cold water settles to offset that added by the pump. This method of using electricity for operating a motor-driven pump has been found much less expensive than using electric heaters.

The city of St. Paul, Minn., has opened bids for the construction of two reinforced concrete reservoirs that will call for an expenditure of about $500,000.

The Board of Public Works of Seattle, Wash., is asking bids for equipment for additions to its Lake Union steam power plant to cost about $300,000.

AUTOMATIC DRAINAGE GATES.

Automatic cast iron gates for the drainage of tidal and flooded lands are now being used extensively by various reclamation districts in California. These gates were first developed for tidal conditions, but it soon became evident there were a great many situations where they would be equally useful, although there was no tidal rise and fall. It has been found that the device may be successfully employed wherever there is land to be drained into a body of water the level of which is sometimes lower than the level of the land itself.

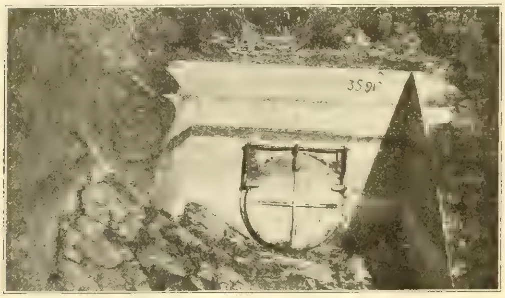


Fig. 1—24-in. Automatic Gate in Reclamation District No. 1001.

The gates are intended for use in connection with pure iron corrugated pipes. They are operated by pressure of water on one side or the other which opens or closes them as conditions require. They are so hung and counter balanced as to be extremely sensitive to water pressure from either direction. The accompanying illustrations show some typical installations.

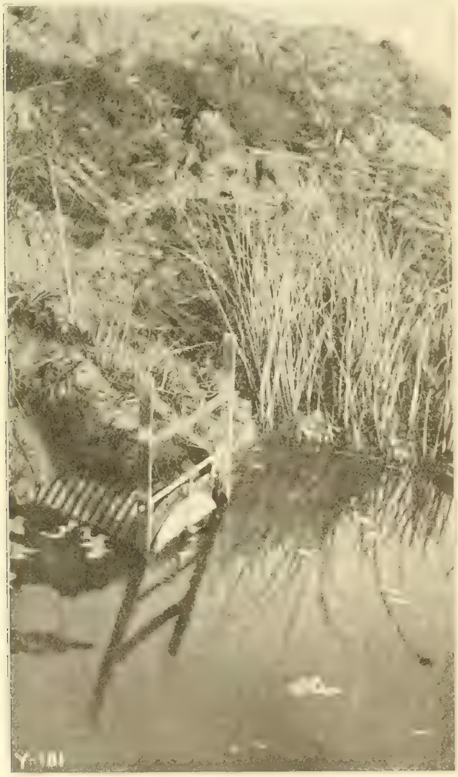


Fig. 2—36-in. Automatic Gate on Russ Island.

Figure 1 shows a 24-in automatic drainage gate attached to 60 ft. of corrugated pipe, installed in Reclamation District No. 1001, 25 miles north of Sacramento, Cal. In this particular case it is used in connection with a standard drain from a water pocket. The pipe is laid through the levee of the diverting canal, the gate being situated within the canal itself.

In Fig. 2 is shown a 36-in. automatic gate attached to 50 ft. of Armco iron corrugated pipe. This installation is on Russ Island, 5 miles east of Vallejo, Cal. The picture was taken just at the turn of the tide, and shows the gate, slightly open, discharging water. The tall metal extensions which are shown were supplied for the purpose of carrying counter-weights which were found to be a hindrance rather than an aid and were subsequently removed.

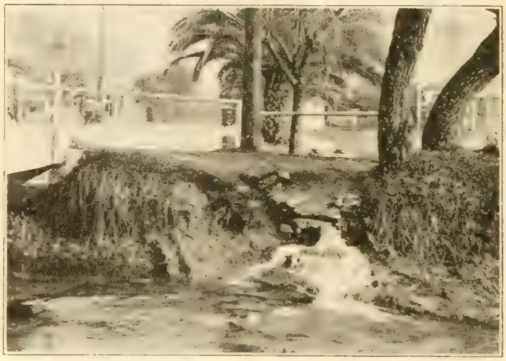


Fig. 3—8-in. Calco Gate in Storm Water Sewer at Fresno.

Figure 3 shows an 8-in. Calco automatic gate in operation discharging storm water from a gutter into an irrigation canal in the city of Fresno, Cal. The gate prevents the water backing up in the pipe, when that in the canal is at a higher level.

REPRODUCTION COST AND LIFE OF WATER WORKS PLANT OF BATH WATER DISTRICT.

Early in 1916 the trustees of the Bath Water District of Bath, Me., acquired the plant of the Maine Water Co. that had been serving the district. This water works taking was unusual in that the determination of the purchase price was left to engineering arbitration. Editorial comment on this feature appears elsewhere in this issue.

The investigations and appraisal for the district were made by Fay, Spofford & Thorndike, consulting engineers, Boston, Mass. In the first report of the trustees of the district much interesting information regarding the physical condition of the plant and its reproduction cost is given. The matter is taken from the report of the engineers and is reprinted below in part:

Expense of Acquiring Plant.

The total expense to the district in the acquisition of the water works was only $18,700.07, made up of the following items:

Engineering services rendered by Fay, Spofford & Thorndike, consulting engineers, Boston, Mass.	$10,386.36
A. S. Merrill, Bath, Maine	178.85
Legal services and expenses of Walter S. Glidden, Esq., counsel, Bath, Maine	5,195.55
One-half of the accounting services and expenses of Edwin L. Pride Company, Boston, Mass., certified public accountants	1,371.55
Charles S. Brown, Bath, Maine, accounting services and expenses at Portland	658.50
James S. Lowell, for making appraisal of rights of way, tools and supplies on hand belonging to the Maine Water Company	150.00
First National Bank of Boston, Mass., printing, certifying and advertising bond issue and procuring legal opinion of same.	500.00
Miscellaneous expense, telephones, telegrams, postage and express, printing, stationery, office supplies, etc.	235.71
Fred H. Thompson, clerk of courts, legal fees on petition, filing, copies, etc.	26.55
Total	$18,700.07

This relatively small expense account is stated to have been made possible only by the method in which the property was acquired. In the Gardiner, Me., case the award was $245,000 and the district's expense was $13,165.39; in the Waterville and Fairfield, Me., cases the award was $503,457.37 and the district's expense $47,084.75; in the Augusta, Me., case the award was $427,135.20 and the district's expense was $47,969.43; and in the Brunswick, Me., case, although much smaller than the Bath one, with an award of only $196,162.09, the expense to the district was $23,480.98. The ratio of expense to the amount of the award is believed to have been smaller in the Bath case than in any other case in New England.

Description and Condition of Physical Plant.

Nequasset Station and Kennebec River Crossing—The water system is supplied by continuous pumping, there being a station at each end of the system. The main pumping plant, known as the Nequasset Station, which is the only one regularly used, is on the shore of and draws from Nequasset Lake, located 2.3 miles east of Bath, in the town of Woolwich. It consists of a pumping house, with engineer's tenement above, a boiler house and a coal pocket, all connected. These structures are of brick or stone, with slate and gravel roofs. The station is equipped with three boilers of the horizontal tubular type, 19¾ ft. long and 72 in. diameter, which were installed by the Geo. F. Blake Mfg. Co. in 1894. In the engine room are a Blake tandem compound, condensing horizontal pump of the duplex plunger type, having a rated daily capacity of 3,300,000 gal., and a Worthington pump of the same type with a rated daily capacity of about 1,500,000 gal. The Blake pump is the one in ordinary use, and is operated continuously except when shut down for repairs. A water pressure of from 95 to 105 lb. per square inch is maintained on the pump, and the average daily pumpage is from 1,000,000 to 1,500,000 gal., or from one-third to one-half of its actual capacity, this reduced pumpage being due to the fact that when the pump was installed it was designed to supply both Bath and Brunswick, at which time the average daily consumption ran as high as 2,250,000 gal. The Worthington pump, which was the original pump installed in the Thompson's Brook Station, is held in reserve for emergency use, and when tested by our engineers appeared to be in good working order.

Nequasset Lake, from which the main water supply is drawn, has a surface area of about .67 of a quare mile. From the Nequasset Station there is a 16-in. supply main, which divides into two 16-in. branches, which cross the Kennebec River as submerged lines for a distance of about ½ mile. The river at this point is of a maximum depth of 50 ft. below mean high water, and is subject to mean tidal variation of about 8 ft. The river bed is of ledge for a distance of about 260 ft. from the Bath shore, from which point there is sand until within 500 or 600 ft. of the Woolwich shore, where a lighter, softer material, apparently containing sawdust, occurs. The river bed is more or less shifting.

The original pipe line, laid in 1894 by Moore & Co. of Boston, is now entirely abandoned. No. 2 line, known as the "Old Line," was laid in 1895 by J. G. Falcon of Evanston, Ill., the patentee of the spherical joint used at intervals on it. The line is made up generally of five sections of Ward joint pipe, connected with Falcon joints. Approaching the deeper part of the river the pipe is protected by riprap, and through the middle of the channel is entirely covered to such a depth that it could not be located, and in fact the Maine Water Co.'s diver says he has never been able to locate it here. No. 3 pipe, or the "New Line," is made up in sections of three ordinary hub and spigot pipes, connected by Falcon joints. It was laid in 1900 by J. G. Falcon, and it rests upon and is attached to bents 12 ft. apart, made up of two piles capped with cross timbers, to which the pipe is fastened by iron straps. The tops of these bents were located just above the river bottom, but at some places the pipe is now covered with sand, while at other places there is 6 ft. or more of clear space below the pipe. Near the Bath shore this line rests on round timber sills anchored to the ledge. The pipe weighs about 230 lb. per foot. The diver's examination showed this line to be in good condition, and tests made under the direction of the engineers, by an engineer of the Pitometer Co. of New York, indicated a leakage of 47,000 gal. per day on the new line and 103,000 gal. per day on the old line.

It should be understood that there is always a normal leakage from every system of water pipes, usually larger when the pipes are under water than when they are under ground, and that the amount of leakage shown by the tests in the large 16-in. river mains is not an excessive quantity, or more than might reasonably be expected.

The examinations of these river crossings were very thorough and complete, extending from Nov. 15 to 27, 1915. The examinations were made by an experienced diver from Boston, who wherever possible used an electric light under water, operated by storage battery. Where the pipes were not buried by sand or riprap they were carefully examined, foot by foot. Where the pipe was buried only a foot or two it was followed by sounding through the sand with an iron rod. Particular attention was paid to the joints. For a distance of about 900 ft. from the middle of the river, easterly, the "Old Line" could not be found at all, after the most careful search. In some places this old line is unsupported for lengths up to 50 ft. and in other places has apparently dropped into depressions cut out by the current under it. The alignment of this "Old Line" is irregular, both horizontally and vertically. The caps and piles of the "New Line" are in excellent condition, although the straps and hoops which fasten the caps to the piles and the pipe to the caps are somewhat rusted. There is room on the cap for another line of pipe alongside of this line. The alignment of the "New Line," with the exception of a sudden drop where the pipe leaves the ledge, is good, both horizontally and vertically.

Thompson's Brook Station—The Thompson's Brook Station, which was the original source of supply, is a complex system, consisting of a small artificial pond known as the Thompson's Brook reservoir; underground connecting tiles beneath the bed of the reservoir; a filter for pond water; an iron caisson well 20 ft. in diameter; a spring from which a line of connecting tiles leads to a caisson; and 83 driven wells. The reservoir was built from 1890 to 1892, and has an earthen dam about 5 ft. in height at its lower end. The reservoir has a maximum depth of about 8 ft., and, assuming an average depth of 4 ft., it would have a capacity above intake of about 5,000,000 gal. Its drainage area is from .60 to .75 of a square mile. There are no dwellings on the immediate drainage area except that of the engineer in charge of the pumping station.

The pumping station itself was built in 1887 as part of the original system and is now simply a reserve station. It consists of a brick pump and boiler room, with slate roof and stone masonry coal pocket. The other buildings are frame structures, including the engineer's house.

The pumping machinery consists of a Worthington horizontal tandem compound condensing steam pump of the duplex plunger type, with about 1,500,000 gal. daily capacity, installed in 1887, and a Worthington 8-in. 2-stage horizontal split casing centrifugal pump, with a capacity of about 2,000,000 gal. daily, direct connected to a Westinghouse constant speed induction motor, installed in the fall of 1914. There are two horizontal return tubular boilers, installed in 1887 by the Bath Iron Works as a part of the original system. The electrically driven centrifugal pump is the one ordinarily used, and the boilers and other machinery are almost never in commission, the boilers never having been retubed. From the Thompson's Brook Station there is a 12-in. supply main which crosses the New Meadows River and is submerged for about 1,500 ft. at high tide and for 360 ft. at low tide, at which later the maximum depth of water is about 20 ft. This 360 ft. consists of Ward joint pipe and the remainder of ordinary hub and spigot pipe. The pipe line on the river bottom rests on very soft, clayed mud, which is always semi-fluid. The condition of the pipe itself is good, so far as external appearance is concerned, but this New Meadows crossing is in fact one of the worst features of the system, and, although fortunately it is only a reserve supply, the trustees are firmly convinced that one of the first improvements which ought to be made to the system is the doing away with this submerged crossing and replacing it by an overhead crossing upon a bridge or some other structure. The Pitometer Co.'s tests showed a leakage of about 99,000 gal. per day in the New Meadows crossing.

Standpipe—The standpipe is part of the original system and is situated on a hill about 1½ miles west of the center of the city. It is 74 feet high and 34 ft. average diameter and contains when full about 506,000 gal. For the normal pressure of 87 lb. at City Hall the water level in the standpipe would be about 21 ft. below its top, corresponding to a storage of 365,000 gal. The elevation of the top is 247.33 ft. above sea level. It was erected by the New England Co. in 1887 of refined wrought iron, of a tensile strength to be not less than 50,000 lb. per square inch. It has been kept well painted and would appear to be in good condition.

Distribution System—At present there are 25 miles of cast iron pipe and 5 miles of wrought iron mains. Leaving out of account the supply mains from the two pumping stations, there are about 23 miles of mains of all kinds and sizes in the city proper, of which 56 per cent is 6 in., 11 per cent is 4 in. and 22 per cent is small wrought iron, and 11 per cent is of sizes larger than 6 in. Test pits opened at various places show that the average depth of cover is from 4 to 5 ft. The amount of rock excavation in the entire system is about 17,500 cu. yd., or nearly 25 per cent of the total excavation.

Hydrants are spaced with reasonable frequency, about 400 ft. apart, in accordance with the contract with the city. They are of the Ludlow or Mathews type, the former predominating. They are mostly two-way, with 6-in. barrel and 4-in. connection to mains, although a few three-way and four-way hydrants are located in important business districts. Their condition seems to be generally good.

Depreciation and Estimated Life of Plant—A few facts bearing on the estimated depreciation and length of life of some of the more important items making up the plant will be of interest:

With regard to the cast iron pipe, examinations made at random at test pits opened by the engineers showed the general condition of the pipes to be good, and in fact in most cases the original tar coating on the surface of the pipe was still bright. With regard to the interior surfaces of the pipes, it was of course impracticable to make extensive investigations.

One of the main troubles afflicting iron pipes is the formation of deposits on the inside, usually in the form of round knobs of greater or less size, known as tubercles. It is generally understood that the formation of these tubercles is caused by the presence in the water of certain chemical elements. If the amount of tubercle is excessive, it affects not only the structural strength of the pipe, but necessarily increases the amount of friction on the water passing through it. In three cases where it was possible to make examinations of pipe interiors only a small amount of tubercle was found, of such a character that it could be readily scaled off and leave a smooth service.

The engineers say:

> Most authorities agree that where the water has no corrosive action on the pipe, the physical depreciation of the latter is almost negligible, but because of the reduced carrying capacity due to tuberculation, and because of obsolescence due to larger sizes being required as the district served gradually develops, there is also a functional depreciation to be considered. The total life of pipes is generally considered to vary with circumstances over a period from 30 to 100 years. Because of the slow growth of Bath, and the probability that for a large part of the system the sizes now used would be adequate for many years, we have adopted a life of 75 years.

With regard to the wrought iron pipe, the engineers estimated a life of 20 years for service pipes and of 30 years for mains. Gate valves, being subject to considerable wear, have an estimated life of from 30 to 75 years. The engineers in their preliminary report adopted a period of 50 years for them. The life of hydrants was estimated at 45 years, of meters at 25 years and of standpipe 50 years.

Investigation shows that the system is fortunately practically free from depreciation of pipes caused by electrolysis, none being discovered in any of the examinations made in places where it would be likely to occur, and with the rails of the electric road properly bonded there is little danger of damage from this cause.

With regard to the filter plant at the Thompson's Brook Station, there is little chance for depreciation. The tile pipes may in course of time become partially filled with sand, some timber work may have to be replaced and expenditures upon the caisson will be required, but, taking it as a whole, a life of from 40 to 75 years may be estimated for this part of the system.

With regard to the pumping equipment at Thompson's Brook and at the Nequasset Station, it may be said that a fair estimate of life would be 35 years for the pumps and 30 years for the boilers.

> The life of pumping machinery of this type is affected not so much by wear as by obsolescence, due to changes in the requirements of the system, and more particularly to developments in design, leading to greater efficiency and more compact types. For these reasons, in spite of the fact that much of the machinery would doubtless actually give service, if kept in good repair, for a longer period than this, the engineers feel that their estimate is liberal.

With regard to the river crossings, an estimated life of 40 years is assigned to the New Meadows crossing, 35 years to the old Kennebec line, laid in 1895, and 40 years to the "new line," laid in 1900.

AGREED SCHEDULE OF REPRODUCTIVE COST.

CAST IRON PIPE.

	Lbs.
302 ft. 20-in. pipe at 160 lb. per ft.	48,320
12,138 ft. 16-in. pipe at 130 lb. per ft.	1,577,940
22,244 ft. 12-in. pipe at 87.6 lb. per ft.	1,948,574.4
3,886 ft. 10-in. pipe at 67 lb. per ft.	260,362
4,362 ft. 8-in. pipe at 50 lb. per ft.	218,100
68,788 ft. 6-in. pipe at 33⅓ lb. per ft.	2,292,933.4
13,802 ft. 4-in. pipe at 21.6 lb. per ft.	298,123.2
Total weight C. I. pipe	6,644,353
3,322 tons at $22.30	$74,080.60
40 tons special castings at $54	2,160.00
	$76,240.60
12½% for contingencies and engineering	9,530.40
Total C. I. pipe	$85,771.00

PIPE LAYING, CAST IRON.

302 ft. 20-in. intake	$ 1,625.00
12,138 ft. 16-in. at 74 ct.	8,982.12
22,244 ft. 12-in. at 59 ct.	13,123.96
3,886 ft. 10-in. at 54 ct.	2,098.44
4,362 ft. 8-in. at 42 ct.	1,832.04
68,788 ft. 6-in. at 38 ct.	26,139.44
13,802 ft. 4-in. at 35 ct.	4,830.70
	$58,631.70
12½% for contingencies and engineering	7,328.30
Total laying C. I. pipe	$65,960.00

WROUGHT IRON, INCLUDING MATERIALS.

16,307 ft. 2-in. at $0.38	$ 6,196.66
376 ft. 1½-in. at $0.34	127.84
8,168 ft. 1-in. at $0.295	2,409.55
598 ft. ¾-in. at $0.235	140.52
1,428 ft. 2-in. surface at $0.23	328.43
	$ 9,203.00
12½% for contingencies and engineering	1,151.00
Total wrought iron pipe	$10,354.00

VALVES, INCLUDING SETTING.

1 valve, 20-in., at $115	$ 115.00
7 valves, 16-in., at $70	490.00
1 valve, 14-in., at $57	57.00
15 valves, 12-in., at $35	525.00
8 valves, 10-in., at $26	208.00
7 valves, 8-in., at $18	126.00
102 valves, 6-in., at $13.50	1,377.00
27 valves, 4-in., at $8.70	234.90
60 valves, 2-in., at $5	300.00
2 valves, 1½-in., at $3.25	6.50
40 valves, 1-in., at $1.75	70.00
3 valves, ¾-in., at $1.25	3.75
3 check valves, 16-in., at $100	300.00
1 check valve, 12-in., at $60	60.00
3 air valves, automatic, at $10	30.00
4 air valves, at $1.75	7.00
166 large C. I. ext. valves at $4.50	747.00
60 C. I. ext. valve boxes at $3.50	210.00
50 Jarecki & Mason iron boxes and covers at $1.10	55.00
	$4,922.15
12½% for contingencies and engineering	615.85
Total valves	$5,538.00

ROCK EXCAVATION.

15,977.64 cu. yd. ledge at $4.40	$70,301.62
1,534.29 cu. yd. loose rock and logs at $2	3,068.58
	$73,370.20
12½% for contingencies and engineering	9,170.80
Total rock excavation	$82,541.00

METERS AND METER BOXES.

Valuation	$ 3,432.00
12½% for contingencies and engineering	429.00
Total meters	$ 3,861.00

HYDRANTS.

14[illegible] Ludlow hydrants at $2[illegible]	$ [illegible]
12½% for contingencies and engineering	[illegible]
45 Mathews hydrants at $41	1,[illegible]
12½% for contingencies and engineering	231.00
Total hydrants	$ [illegible]

SERVICES.

5 services, 6-in., at $36	$ 180.00
6 services, 4-in., at $25	150.00
1 service, [illegible]-in., at $[illegible]	[illegible]
4[illegible] services, 2-in., at $[illegible]	[illegible]
[illegible] services, 1½-in., at $[illegible]	1,[illegible]
260 services, 1-in., at $15	3,900.00
1,[illegible] services, ¾-in., at $11	1,[illegible]
354 secondary services at $5	1,770.00
	$26,546.00
12½% for contingencies and engineering	[illegible]
Total services	$29,864.25

ROCK EXCAVATION ON SERVICES.

Valuation	$[illegible]
12½% for contingencies and engineering	3,731.25
Total rock excavation on services	$33,581.25

SHUT-OFF OR DISCONTINUED SERVICES.

1 Service, 2-in. at $26.00	$ 26.00
2 Services, 1-in. at $2[illegible]	[illegible]
73 Services, ¾-in. at $16.00	1,168.00
	$1,246.00
12½% for contingencies and engineering	[illegible]
Total	$[illegible]

DRINKING FOUNTAINS.

[illegible] Fountains at $11[illegible]	$ [illegible]
12½% for contingencies and engineering	[illegible]
Total	$ [illegible]

STANDPIPE AND FOUNDATION.

Valuation	$[illegible]
12½% for contingencies and engineering	1,253.00
Total	$[illegible]

FILTER SYSTEM AT THOMPSON'S BROOK.

Valuation	$ 5,775.00
12½% for contingencies and engineering	[illegible]
Total	$ 6,497.00

THOMPSON'S BROOK RESERVOIR.

Dam and [illegible]	$ 1,[illegible]
12½% for contingencies and engineering	249.00
Total	$ [illegible]

CAISSON.

15-in. conduit	$ 4,[illegible]
12½% for contingencies and engineering	569.50
Total	$ 5,125.50

DRIVEN WELLS AND SIPHON TANK.

Valuation	$ 4,500.00
12½% for contingencies and engineering	563.00
Total	$ [illegible]

THOMPSON'S BROOK PUMPING STATION.

Engine house, tenement, boiler house, coal pocket, filter and caisson house	$ 9,557.00
12½% for contingencies and engineering	1,195.00
Total	$10,752.00
Boilers	$ 2,350.00
Pump [illegible] air pump	1[illegible]
	$ 2,509.00
12½% for contingencies and engineering	[illegible]
Total	$ [illegible]
Boiler foundation	$ 150.00
Chimney and foundation	1,100.00
Electrical pump and pole line	3,100.00
Pump foundation	[illegible]
Hot well, feed water heater and vacuum gauge	140.00
Suction well	[illegible]
	$ 5,640.00
12½% for contingencies and engineering	705.00
	$ 6,345.00
Steam piping	$ 950.00
12½% for contingencies and engineering	119.00
	$ 1,069.00
Pumps	$ 4,[illegible]
12½% for contingencies and engineering	563.00
	$ 5,063.00
Stoves and stove pipe	$ 60.00
12½% for contingencies and engineering	7.50
	$ [illegible]
Cast iron pipe and specials	$ 1,[illegible]
12½% for contingencies and engineering	175.00
	$1,575.00

SIDE TRACK.

Cost of siding at Thompson's Brook	$ [illegible]
12½% for contingencies and engineering	47.00
	$ [illegible]

NEQUASSET PUMPING STATION.

Pumping station and [illegible], ice house, hen house and shed	$16,735.00
12½% for contingencies and engineering	[illegible]
	$[illegible]
3 boilers, flues, damper and setting	$ 5,000.00
Steam engine and electric generators	500.00
	$ 5,500.00
12½% for contingencies and engineering	687.50
	$ [illegible]
Steam piping [illegible]	$ [illegible]
Chimney and chimney foundation and specials	3,500.00
Cesspool and sewer pipe	275.00
	$ 5,775.00
12½% for contingencies and engineering	[illegible]
Total	$ 6,496.00
[illegible] foundation	[illegible]
[illegible]	[illegible]
[illegible] pipe [illegible]	[illegible]
Cofferdam in addition to other items	575.00
	$ [illegible]
12½% for contingencies and engineering	926.25
Total	$ [illegible]
[illegible]	$ [illegible]
12½% for contingencies and engineering	2,046.00
Total	$ [illegible]

SIDE TRACK AT NEQUASSET STATION.

Cost of a siding at Nequasset Station and culvert and filling	$ 2,300.00
12½% for contingencies and engineering	[illegible]
Total	$ [illegible]

NEW MEADOWS RIVER CROSSING.

Extra for Ward pipe and joints, tide work and weight of iron	$1,100.00
12½% for contingencies and engineering	[illegible]
Total	$ [illegible]

BACK RIVER.

2,000 ft. 16-in. pipe, weighing 130 lb. per foot, at $22.00 per ton; 2,000 ft. of 16-in. at $1.25, and 20 cu. yd. concrete	$ 5,500.00
12½% for contingencies and engineering	[illegible]
Total	$ [illegible]

KENNEBEC RIVER.

Line built [illegible]	$ [illegible]
12½% for contingencies and engineering	4,912.00
Total	$ [illegible]
Line built 1895	$30,000.00
12½% for contingencies and engineering	3,750.00
Total	$33,750.00

WATER RIGHTS.

Valuation	$ [illegible]

OFFICE BUILDING AND HEATING SYSTEM.

Valuation	$ 6,000.00
12½% for contingencies and engineering	750.00
Total	$ [illegible]

IMPROVED STREETS OVER CAST-IRON MAINS.

6,381 ft. state road macadam.	
17,078 ft. good macadam.	
8,614 ft. poor macadam.	
1,615 ft. granite blocks.	
511 ft. bituminous macadam.	
1,439 ft. gravel surface.	
1,458 ft. tarvia.	

IMPROVED STREETS OVER WROUGHT-IRON WATER PIPES.

1,206 ft. state macadam.	
6,376 ft. good macadam.	
3,389 ft. poor macadam.	
820 ft. granite blocks.	
130 ft. bituminous macadam.	
96 ft. gravel surface.	
674 ft. tarvia	$ 6,223.00
12½% for contingencies and engineering	778.00
Total	$ 7,001.00
Grand total	$549,491.00
Deduct agreed value of water rights	5,000.00
Agreed reproduction cost	$544,491.00
Tools, supplies on hand, rights of way, real estate, etc.	14,517.00
Total agreed cost of reproduction, new, of the physical plant as of Jan. 1, 19[illegible]	$5[illegible]

PIPE SCREWING MACHINE.

A machine for screwing up pipe has recently been brought out by the Buckeye Traction Ditcher Co., Findlay, O. The machine is designed to screw up pipe of the larger sizes, particularly 6 and 8 in. and 10 and 12 in. The No. 1 machine will handle 6 and 8-in. pipe while the No. 3 will handle 10 and 12-in. pipe. The illustration shows the machine for handling 6 and 8-in. pipe. A larger machine for 10-in. and 12-in. pipe also is made. This is exactly the same in design as the smaller one except being proportionately heavier throughout.

The machine is equipped with a four-cylinder motor which on the No. 1 type develops 25 H.P. Apron or caterpillar wheel are furnished which make it possible to get through fields and in places where a machine would be expected to run. The machine is equipped with a two-speed forward and reverse mechanism for driving on the road, giving a speed of 2¼ and 3½ miles per hour. The power is transmitted to the propeller shaft at the back end of the machine through a multiple disc friction clutch and connects with an enclosed type transmission running in oil. From this the power is transmitted by a roller chain to a bevel pinion and large bevel gear which is connected to the shaft driving the propeller through universal joints.

The propeller shaft proper is made up with a piece of extra heavy 5-in. gas pipe inside of which is telescoped a 2½-in. square shaft to which the wrench head is connected by universal joint. This shaft can be extended within its limit, and the propeller shaft also can be extended up or down or sideways at will.

The wrench head is provided with three tool steel jaws which grip the sleeve of the pipe automatically. To release this head it is only necessary to reverse the propeller shaft and it releases automatically. This head is also provided with slots for reversing the jaws so pipe can be unscrewed as well.

The machine is operated by one man. In addition two men handle the wrench head, these men being selected from the crew helping to get the pipe in place and started in the coupling.

The manufacturers have records of the smaller machine screwing up 350 joints a day under ordinary conditions. The operating cost is stated to be about as follows:

Machine for Screwing Up Pipe.

Figuring on $5 per day for operator; 20 gal. of gasoline at 20 ct. per gallon, $4; oil and grease, $1; average repairs, figuring on 300 days per year, $1 per day; depreciation and interest on investment, $1 per day; making a total of $12 per day running expenses for the smaller machine.

The weight of the smaller machine is 16,000 lb., and the price is $2,500. The larger machine weighs 20,000 lb. and sells for $3,000. Either machine can be loaded easily on a flat car without dismounting any of the parts.

DEFINITION OF TERMS USED IN SEWERAGE AND SEWAGE DISPOSAL PRACTICE.

The Committee of Sewerage and Sewage Disposal of the Sanitary Engineering Section of the American Public Health Association at the annual meeting of the association last fall at Cincinnati, O., submitted a report defining the terms used in sewerage and sewage disposal practice. The report was tentative and was submitted with the hope that it would bring out a full discussion of the subject. It is the purpose of the committee to amend these definitions in accordance with the weight which may be given in the discussions, with the view of establishing terms that may be generally acceptable to all engaged, or interested, in work of this character. The committee consisted of the following:

Chairman, George S. Webster, Philadelphia, Pa.; Frank A. Barbour, Boston, Mass.; Kenneth Allen, Municipal Bldg., New York City; Langdon Pearse, Chicago, Ill.; W. C. Hoad, Ann Arbor, Mich.

The suggested definitions follow:

Sewage is the spent water supply containing the wastes from domestic, industrial or commercial use, including such surface and ground water as may enter the sewer.

Domestic Sewage is that discharged from residences or institutions, and contains water-closet, laundry and kitchen wastes.

[1]Industrial Wastes are the liquid wastes resulting from the processes employed in industrial establishments.

Street Wash is the liquid flowing on and from the street surface.

Surface Water is that portion of the precipitation which runs off over the surface of the ground.

Storm Water is that portion of the precipitation which runs off over the surface of the ground during a storm and for such a short period following a storm as the flow exceeds the normal or ordinary run-off.

Ground Water is that which is standing in, or passing through, the ground.

Drain is a conduit intended to carry storm, surface and ground water.

Sewer is a conduit for carrying sewage.

Common Sewer is a sewer in which all abuttors have equal rights of entrance and use.

House Connection is a pipe leading from a building to a common sewer.

Lateral Sewer is a sewer which does not receive the sewage from any other common sewer.

[2]Submain or Branch Sewer is a sewer into which the sewage from two or more lateral sewers is discharged.

Main or Trunk Sewer is a sewer into which the sewage from two or more submain or branch sewers is discharged.

[3]Separate Sewer is a sewer which is intended to receive only sewage and not storm or surface water.

Combined Sewer is a sewer intended to receive both sewage and storm and surface water.

Intercepting Sewer is a sewer generally laid transversely to the general sewer system to intercept all the sewage collected by the sewers of a separate system or the dry weather flow of sewage, and such additional storm and surface water as may be determined, from a combined system.

Relief Sewer is a sewer intended to carry a portion of the flow from a district already provided with sewers of insufficient capacity, and thus prevent overtaxing the latter.

Sewer System is the collecting system of sewers and appurtenances, together with such small pumping stations as may be required to lift the sewage from low-level districts.

Combined System is a system of combined sewers.

Separate System is a system of separate sewers.

Sewerage Works comprise the sewer system, main pumping stations, treatment works, means of disposal of effluent and sludge, and all other works necessary to the complete collection, treatment and disposal of the sewage.

Manhole is a shaft, or chamber, leading from the surface of the ground to the sewer, large enough to enable a man to gain access to the latter.

Lamphole is a small vertical pipe or shaft leading from the surface of the ground to the sewer, for admitting a lantern or reflected light for purposes of inspection.

Wellhole or Drop Manhole is a vertical shaft in which sewage is allowed to fall from one sewer to another at a lower level.

Inlet is a direct connection between the surface of the ground and the sewer, for the admission of surface or storm water.

Catch Basin is a chamber inserted in an inlet to prevent the admission of grit and other coarse material into the sewer.

Flush Tank is a tank in which water or sewage is accumulated, to be quickly discharged later, for the purpose of flushing the sewer.

Regulator is a device for controlling the quantity of sewage admitted to an intercepting sewer.

Outlet is the end of a sewer or drain from which its contents are finally discharged.

Storm Overflow is a weir or orifice for permitting the discharge from a combined sewer of that portion of the storm flow in excess of that which the sewer is intended to carry.

Sewage Disposal is a generic term applied to the act of disposing of sewage matter by any method.

[4]Sewage Treatment is the process to which sewage is subjected in order to partially remove its impurities and render it fit for final discharge.

Contamination is the introduction into a water of bacteria or other substances which tend to render it unsuitable for domestic use.

Pollution is the introduction into a water of substances of such character and in such quantity that they tend to render the body of water or river objectionable in appearance, or to cause it to give off objectionable odors.

Influent in sewage practice is a term which applies to sewage that flows into any sewage treatment device.

Effluent in sewage practice is a term which applies to sewage that flows out of any sewage treatment device.

Putrescibility is the capability of sewage, effluent, or wet sludge, to putrefy under the conditions to which it is subjected.

Stability is the capability of sewage or effluent to resist putrefaction under conditions to which it is subjected.

Relative Stability is the ratio of available oxygen to the oxygen required to prevent putrefaction, expressed in per cent.

Clarification is the removal of the suspended and colloidal matters.

Suspended Solids are the solids, both organic and inorganic, that are not held in solution in a sewage or effluent; these solids being quantitatively determined in the laboratory by retention on filter paper.

Settling Solids are those suspended matters which will subside in quiescent sewage in any specified length of time.

Colloidal Matter is suspended matter which is so finely divided that it is no longer acted on by gravity, and remains suspended indefinitely, yet will not pass through a parchment membrane in the ordinary process of dialysis.

Screens.—A screen is a device containing openings of proper size to retain a part of the suspended matter of sewage.

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[1] In the opinion of the committee the term "Industrial Wastes" is preferable to "Trade Wastes."

[2] The committee is of the opinion that preference should be given to the term "Sub-main Sewer" rather than to "Branch Sewer."

[3] In the opinion of the committee the use of the term "Separate Sewer" is preferable to "Sanitary Sewer," which latter term should be discontinued.

[4] The term "Sewage Purification" should be abandoned.

Coarse Screen is one having openings in excess of ½ in. in least dimension.

Fine Screen is one having openings of ½ in., or less, in least dimension.

Bar Screen is one composed of parallel bars or rods.

Mesh Screen is one composed of a fabric, usually of wire.

Grating.—A grating consists of two sets of parallel bars in the same plans, the sets intersecting at right angles.

Perforated Plate Screen is one made of perforated plates.

Band Screen is one consisting of an endless band or belt which passes over upper and lower rollers.

Wing Screen is one having vanes, uniformly spaced, which rotate on a horizontal axis.

Drum Screen is one in the form of a cylinder or cone, consisting of perforated plates or a wire mesh which rotates on a horizontal axis.

Disc Screen consists of a rotating circular perforated disc, with or without a central truncated cone of similar material mounted on the center.

Cage Screen consists of a cage having three sides made of parallel bars or rods, so arranged that it may be lowered into the sewage, and raised therefrom for cleaning.

Tank Treatment is the detention of sewage or sewage sludge in tanks, either quiescent or with continuous flow.

Grit Chamber is a chamber or enlarged channel in which the cross section of sewage flow is so designed that the velocity is such that only heavy solids, such as grit and sand, are deposited, while the lighter organic solids are carried forward in suspension.

Sedimentation Tank is a tank for the removal of suspended matter either by quiescent settlement or by continuous flow at such a velocity and time of retention as to allow deposition of suspended matter.

Dortmund Tank is a vertical sedimentation tank, usually cylindrical, in which the raw or partially treated sewage enters the lower part, flows upward and passes out near the top. The sludge is drawn before it becomes septic from the conical or hopper-shaped bottom.

Hydrolytic Tank is a tank in which by biological processes a portion of the suspended matter is converted into liquid and gaseous form.

"Septic" Tank is a horizontal, continuous-flow, one-story sedimentation tank through which sewage is allowed to flow slowly, to permit suspended matter to settle to the bottom, where it is retained until anaerobic decomposition is established, resulting in the changing of some of the suspended organic matter into liquid and gaseous substances and a consequent reduction in the quantity of sludge to be disposed of.

Travis Tank is a 2-story tank consisting of an upper, or sedimentation, chamber, with steeply sloping bottom, terminating in one or more slots through which the solids may slide as deposited into the lower or sludge digestion chamber, through which a predetermined portion of the sewage is allowed to pass for the purpose of seeding and maintaining bacterial life in the sludge and carrying away decomposition products, thus inducing digestion of the sludge attended by its reduction in volume.

Imhoff or Emscher Tank is a 2-story tank consisting of an upper, or sedimentation, chamber, with steeply sloping bottom, terminating in one or more slots through which the solids may slide as deposited into the lower or sludge digestion chamber—these slots being trapped so as to prevent the rise of gas and solids from the lower chamber—the lower chamber being provided with vents for the escape of the gases, the tank being so constructed as to facilitate the passage of the sewage quickly through the upper chamber and prevent the flow of sewage through the digestion chamber, and so operated that the sludge may be thoroughly decomposed, rendered practically free from offensive odor and so filled with gas that it can be readily drawn off and dried.

Activated Sludge Process consists in the agitation of a mixture of sewage with about 15 per cent or more of its volume of bacterially active liquid sludge in the presence of ample atmospheric oxygen for a sufficient period of time to at least coagulate a large proportion of the colloidal substances, followed by sedimentation adequate for the subsidence of the sludge flocculi; the activated sludge having been previously produced by aeration of successive portions of sewage and maintained in its active condition by adequate aeration by itself or in contact with sewage.

Chemical Precipitation consists in adding to and thoroughly mixing with the sewage such chemicals as will, by reaction with each other or with the ingredients of the sewage, produce a flocculent precipitant, and subsequent sedimentation.

Sludge is the suspended matter of the sewage deposited in tanks or intercepted at the surface of filters, mixed with more or less water.

Sludge Digestion is the biological process by which organic matter in sludge is gasified, liquefied, mineralized or converted into stable organic matter.

Separate Sludge Digestion is the digestion of sludge in tanks entirely independent from the tanks in which it is produced.

Sludge Drying Bed is a natural or artificial layer of porous material upon which sludge is dried by drainage and evaporation.

Sludge Concentration is the process of reducing the volume of sludge and increasing its proportion of solids by allowing it to stand in a suitable tank until the solids settle down and drawing off the relatively clean water at the top.

Sludge Drying is the process of drying sludge by natural or artificial heat.

Sludge Dewatering is the process of removing a portion of the water contained in the sludge by draining, pressing, centrifuging or by other natural or mechanical processes.

Sludge Pressing is the process of dewatering by the exertion of pressure, the solids being retained by a cloth fabric which permits the water to pass through it.

Sludge Cake is the mass of dewatered sludge resulting from sludge pressing.

Scum is a floating mass of sewage solids buoyed up in part by entrained gas or grease, forming a greasy mat which remains on the surface of the sewage.

Screenings constitute the material removed from sewage by screens.

Grit is the heavy mineral matter deposited from sewage.

Sleek is the oily film of microscopic thickness present on the surface of waters about and often extending a considerable distance from sewer outlets.

Sewage oxidation is the process whereby through the agency of bacteria, in the presence of air, the organic matter is converted to a more stable condition or into mineral matter.

Irrigation is the generic term applied to the process of sewage treatment in which the sewage is applied to land for the primary purpose of purifying the sewage and the secondary purposes of supplying water and fertilizer to crops.

Surface Irrigation is the process in which sewage is applied to and distributed over the surface of cropped ground.

Subsurface Irrigation is the process in which sewage is distributed beneath the surface of the ground by means of open-jointed pipes.

Sewage Farm is an area of land on which crops are raised and to which sewage is applied on or beneath the surface of the soil and is absorbed by vegetation, evaporates or percolates to the ground water.

Intermittent Filter is a natural or artificial bed of sand or other fine-grained material to which sewage is intermittently applied in doses, and which by its capillarity holds the sewage for a time sufficiently long, in the presence of air, to effect by biological processes a high degree of purification.

Contact Bed is a water-tight basin filled with coarse material, such as broken stone, in contact with which the sewage is for a time held by control of the underdrains—the cycle of operation involving periods of filling, standing full, emptying and resting empty—so regulated as to secure such contact with the bacterial films adhering to the surface of the coarse material, and such aeration of the bacterial surfaces as may be required to oxidize the sewage.

Slate Bed is a tank filled with slabs of slate or other similar material, laid horizontally and spaced an inch or more apart vertically, equipped so that it may be filled with sewage, allowed to stand full for a definite period of time, drained and allowed to stand empty for a time, for the purpose of oxidizing the organic matter deposited upon and adhering to the slates.

[5]Trickling Filter is an artificial bed of coarse material, such as crushed stone or clinkers, over which the sewage is distributed as a spray from fixed nozzles or as a film from moving distributors, through which it trickles to the underdrain system, coming in contact with the bacterial films adhering to the surface of the stones, and in which such aeration of the bacterial surfaces as may be required to oxidize the sewage is afforded.

Dosing Apparatus is the apparatus used for regulating the application of sewage to filters or for applying the required quantity of chemicals to sewage.

Sprinkler Nozzle is a nozzle used for applying sewage in the form of a spray to trickling filters.

Distributor is a movable pipe or channel which distributes sewage upon the surface of a trickling filter. There are two types of distributors—the rotary and the traveling; the rotary moves about a central axis with delivery to a circular filter; the traveling moves back and forth the length of a rectangular filter.

Dosing Tank is a tank into which raw or partially treated sewage is introduced and held until the desired quantity has been accumulated, and then discharged at such a rate as is necessary for the distribution essential to the subsequent treatment.

Disinfection is the destruction by the agency of some chemical, of a large percentage of the bacteria in sewage or contaminated water, so as to reduce the danger of infection to a negligible quantity.

Sterilization is the destruction, by the agency of some chemical, of all the bacteria in sewage or contaminated water, including their spores.

Nuisance (in relation to a polluted stream) is a condition which is offensive to the sense of sight or smell.

A clean river in regard to sewage, is one which gives no sensuous evidence of sewage pollution and from which a wholesome drinking water can be obtained by practicable methods of water purification.

CIRCULAR SLIDE RULE FOR RE-GEARING METERS.

A circular slide rule for re-gearing water meters has been devised by F. L. Bock, assistant engineer, Distribution System of the Water Division of St. Louis, Mo. The arrangement is shown in the accompanying illustration.

It is an adaptation of the regular logarithmic slide rule principle, with instructions for use of non-technical help when re-gearing meters to register accurately. There are four steps in its use and the setting as given by the last one affords a choice of every gear combination that will make the meter register accurately. To use the rule, it is necessary to know the per cent of water registered by the meter with the change-gear numbers. The directions appear on its face.

The rule, in brief, consists of two thin concentric discs and a pointer, all pivoted, to rotate from the center. The circular form is stated to be an advantage over the straight in its lower cost and elimination of re-setting the scales in the last step as often would occur with a straight rule in order to get the proper range of combinations.

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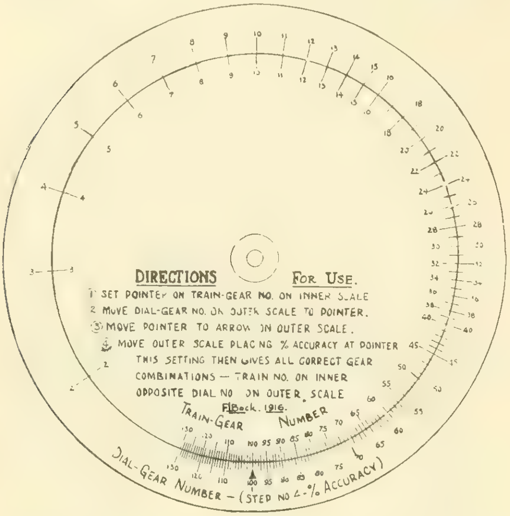
[5] The committee is of the opinion that the term "Trickling Filter" is preferable to the term "Sprinkling Filter" or "Percolating Filter."


DIRECTIONS FOR USE.
1 SET POINTER ON TRAIN-GEAR NO. ON INNER SCALE
2 MOVE DIAL-GEAR NO. ON OUTER SCALE TO POINTER.
3 MOVE POINTER TO ARROW ON OUTER SCALE.
4 MOVE OUTER SCALE PLACING % ACCURACY AT POINTER
THIS SETTING THEN GIVES ALL CORRECT GEAR
COMBINATIONS — TRAIN NO. ON INNER
OPPOSITE DIAL NO ON OUTER SCALE
F. Bock. 1916.
TRAIN-GEAR NUMBER
DIAL-GEAR NUMBER — (STEP NO 4-% ACCURACY)

Circular Slide Rule for Re-Gearing Meters.

FORMS FOR GROINED ARCH FLOOR CONSTRUCTION OF A RESERVOIR.

The new 1,200,000-gal. concrete reservoir, completed last spring for the city of Sioux Falls, S. Dak., has a beam and slab roof, slab walls and slab bottoms next to the walls on each side, the remainder of the bottom being of the inverted groined arch type. For the construction of these groined arches the contractor devised the steel frame or templet shown in Fig. 1. Two of these frames were used, one being set while the other was being filled. The frames were made of 1½-in. angles and were set on 2x6 stringers placed 12 ft. apart across the entire structure. They were so light that they could be moved easily from place to place, and the foundation for each column built in one piece. Concrete was piled in the form and tamped until the frame was filled, a 1:1 mix being put in for the finish. The surface was smoothed off with a screed passed along the upper side of the corner angles of the frame. The form was then moved and the finishing completed by a mason with a trowel. The contractors for the reservoir were Fanebust Bros., Sioux Falls, S. Dak. Dabney Maury, Chicago, Ill., was the Consulting Engineer for the city.

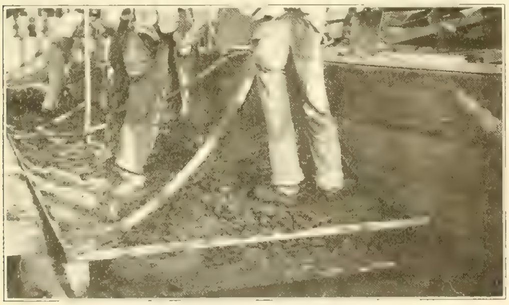


Fig. 1—Steel Frame for Groined Arches.

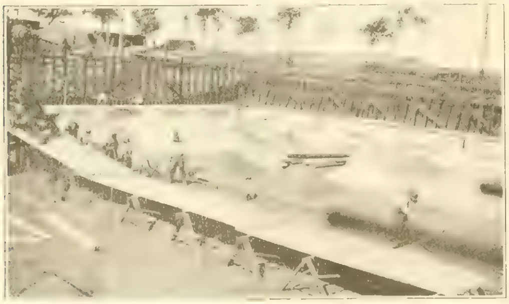


Fig. 2 -Completed Groined Arches at Sioux Falls Reservoir.

NEWS LETTERS.

St. Louis Items.

J. E. Lyman, a good all around railroad superintendent, is here idle at present.

Ed Healy is going to build an addition to his big crusher plant near Cape Girardeau, Mo.

The Heman Construction Co., St. Louis, Mo., were awarded the contract for constructing fifteen ammunition buildings for the government at Rock Island, Ill.

The Frazier-Davis Construction Co. of St. Louis, Mo., are going to put in the foundations for the fifteen government ammunition buildings for the Heman Construction Co. at Rock Island, Ill.

Robert Watton, 84 years old, one of the men who built the first fifteen miles of the Missouri Pacific R. R., died at his home here Feb. 1 of a complication of diseases. Mr. Watton came from England and settled in St. Louis in 1852. He was one of the first employes of the Missouri Pacific R. R. and superintended the construction of the line from the old Seventh street station to Kirkwood, Mo. After working for the railroad for nearly thirty-four years he retired and lived with his daughter, Mrs. Mary Frein.

Contractors when in want of labor or work for their outfits write Koenig's Labor Agency, 612 Walnut street, St. Louis, or 503 Delaware street, Kansas City, Mo. A. B. KOENIG.

PERSONALS.

Duncan Buie has been appointed state highway engineer of Louisiana, with offices at New Orleans.

C. L. Dimmit has been appointed city engineer of Redwood City, Cal., succeeding Arthur M. Porter, resigned.

C. A. Woodworth recently resigned as county engineer and has opened an office at Water Grove, Ia., for private practice.

G. W. Ellis, formerly city engineer and superintendent of water works at Osage City, Kan., has been appointed city engineer of Pratt, Kan.

L. K. Rourke, formerly Commissioner of Public Works of Boston, Mass., has accepted a position in an advisory capacity with the Chile Exploration Co. and the Braden Copper Co. of New York City.

Gen. Geo. W. Goethals has opened consulting offices in the Wall Street Exchange building, 43 Exchange place, New York. He has associated with him experienced specialists and will engage in a general consulting practice in civil, electrical, mechanical and hydraulic engineering. Special attention will be given to examinations and reports on canals, harbors, dry docks, terminals, dams, water power development, water supplies, purification of tropical waters, refrigeration, reinforced concrete structures, organizations, management and public utilities.

OBITUARIES.

Lyman E. Cooley, consulting engineer, Chicago, Ill., died suddenly Feb. 3 of apoplexy. Mr. Cooley was graduated from Rensselaer Polytechnic Institute in 1874. He was professor of Engineering at Northwestern University for the next three years. From 1878 to 1884 he was in the U. S. Engineer Service, engaged in the improvement of the Mississippi and Missouri rivers. In 1885 he became connected with the Chicago Sanitary and Ship Canal. He was chief engineer for several years, then became trustee and consulting engineer.

INDUSTRIAL NOTES.

The Blaw Steel Construction Co., Pittsburgh, Pa., has opened an office at No. 6 Beacon street, Boston, Mass. This office will be under the charge of Irving Burrows, formerly with the New York sales department and prior to that time with the Aberthaw Construction Co.

The Gramm-Bernstein Motor Truck Co., of Lima, O., has effected arrangements with the R. M. Taylor Corporation, New York City, whereby the latter concern will control exclusively, both wholesale and retail sales, and all service stations of the Gramm-Bernstein truck in the states of New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, Maine, Vermont, New Jersey, Pennsylvania, Delaware, Maryland and the District of Columbia. Executive offices have been established in the Brokaw building, Broadway and Forty-second street. The capitalization of the Gramm-Bernstein Motor Truck Co. was recently increased from $500,000 to $4,000,000, and plans are now being made for a new administration building, additional factory facilities and much new equipment.

The Trus-Con Laboratories, Detroit, Mich., held its first sales convention on Jan. 30-Feb. 3. Over fifty district managers and salesmen from the Pacific Coast to the far South, the East and Canada were in attendance. The sessions of the Trus-Con conventions were held in the Hotel Statler, the proceedings opening on the morning of Jan. 30. The general director, R. A. Plumb, gave the address of welcome, followed by G. F. Hilton, sales manager, who outlined the ideas of the convention proper. Following this, E. M. Barrett, secretary of the National Salesmanship's Congress, addressed the meeting on "The Big Idea in Salesmanship." The next three days were spent in discussion of the various Trus-Con materials. The session on Integral Waterproofing was particularly interesting, due to the presence of Prof. Alfred H. White, professor of chemical engineering, University of Michigan, who spoke on the "Volume Changes in Concrete." The sales convention will from now on be an annual affair. It is hoped, however, that next year some of the foreign representatives, of whom there are approximately fifty, will likewise be in attendance. The laboratories' management consists of R. A. Plumb, general director; C. S. Potter, assistant general director; G. F. Hilton, sales manager; E. G. Frank, promotion director, and L. O. Gilbert, manufacturing director.

Dirt Mover and Pit Owner Issue
of

Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

First Wednesday Each Month............Roads and Streets......$1 Yearly
Second Wednesday Each Month, Waterworks and Hydraulics.......$1 Yearly
Third Wednesday Each Month....Dirt Mover and Pit Owner.......$1 Yearly
Fourth Wednesday Each Month.....Buildings and Structures.....$1 Yearly
Fifth Wednesday.......Planning and Management Quarterly...25 cts. Yearly
Every Wednesday..$3 Yearly
Any Two or More Monthly Issues, 75 Cents Each Per Year
Contract News Appears in All Issues

Volume XLVII. CHICAGO, ILL., FEBRUARY 21, 1917. Number 8.

THE "DIRT MOVER AND PIT OWNER MONTHLY" ISSUE OF "E. & C."

Last July we began devoting one issue of Engineering and Contracting each month to articles relating to excavation and to the manufacture of sand, gravel and crushed stone. From time to time we have received suggestions that it might be wise to revive the name of "Dirt Mover," a periodical that was purchased by us and subsequently made a part of "E. & C." We have decided that the suggestion is a good one.

To our new subscribers a word of explanation about the "Dirt Mover" may be of interest. The periodical of that name was started in 1895 and was purchased by us in 1908. It had built up a large circulation among excavating contractors and their superintendents, and it had also a considerable circulation among owners of sand and gravel pits. In short, its special appeal was to all those whose business it was to excavate and transport earth and rock—the "dirt movers," as they are known in the vernacular of the trade.

After the purchase of the "Dirt Mover" we continued to publish it as a separate periodical for nearly a year. Manufacturers who advertised in both the "Dirt Mover" and "E. & C." urged the consolidation of the two periodicals because both papers supplied much the same sort of information to contractors. To differentiate contractors on the ground that they were "small" or "large," "local" or "national," appeared to us to be fundamentally illogical. Accordingly the "Dirt Mover" was absorbed by the larger paper, "E. & C."

Now that "E. & C." publishes four rotated monthly special issues, it becomes not only possible but perfectly logical to revive the well known title of the "Dirt Mover" and to apply it to our excavation monthly issue. Also it seems desirable to add thereto the title "Pit Owner," in order to make it perfectly clear that many articles in this issue relate directly to the manufacture of products excavated from pits, namely sand, gravel and crushed stone.

We have published a very large volume of usable information for "pit owners" during the past 11 years, and in that same period many of our readers have gone into the sand, gravel and stone business. With increasing use of these products for concrete and for road construction, the business of manufacturing pit products has grown enormously. Contractors were probably the first class of men to evolve into "pit owners"; for, beginning by supplying themselves with sand, gravel and stone, it was a natural step for them to supply other people with products from their pits. It is certain that this was the step taken by some hundreds of our contractor readers.

To those pit owners who are not yet subscribers for the "Dirt Mover and Pit Owner Monthly," it may be desirable to point out that most of the methods used by contractors in excavating and handling "dirt" are applicable somewhere in excavating and handling sand and gravel. Illustrative of this is the article in this issue by Mr. Willard, on the use of water for transporting sand and gravel from the face of the pit to the screens. This method of "hydraulicking and sluicing" gravel was originally invented by a California gold miner. Later it was adopted by dirt moving contractors for building railroad embankments. Then the same "dirt movers" began to build earth dams by this method. Finally some shrewd Pacific Coast "dirt mover" decided to excavate and transport sand and gravel by means of water to the bins that fed his concrete mixer. And now, in this issue, you read for the first time how a western pit owner is using the method and is even hauling the gravel uphill to dump it into the sluices that carry it to the screens. Obviously this hydraulic method is not economically applicable in every gravel pit. It may not be applicable in one pit in fifty, but if you own that fiftieth pit this article may be the means of your saving a great deal of money every year.

So it is easily seen that the "dirt mover" and the "pit owner" have much that they can learn from one another. It is our function, therefore, to secure these practical hints and to present them every month in a manner that is readily understandable.

CONTRACTORS, AWAKE!

Eleven years ago the first of January this journal fired the first gun of alarm about the future of the contracting business. We pointed out that socialistic and labor union efforts were directed toward the complete elimination of the contract system and the substitution of the day labor system of doing public work. There were, however, relatively few contractors at that time who saw the trend of events as we saw them.

Today there is scarcely a municipal contractor who is not doing some very serious thinking about his business future; for in several cities, notably Minneapolis, municipal contracting has already been eliminated, and in other cities there are organized movements on foot to accomplish the same result.

Only three weeks ago we called attention to the fact that a large part of the sewer work of Detroit is being done by day labor, and that no detailed records of cost are being kept, according to a report by Mr. H. S. Morse, formerly Engineer of Sewers of Cincinnati. Mr. Morse indicates a condition in the sewer department of Detroit that amounts to economic chaos.

In an editorial note in another column we call attention to a movement now on foot in Los Angeles to make public work contracting illegal. But what we wish to call particular attention to at this time is the attempt that is being made to induce the legislators of Utah to pass a bill that is intended to put municipal contractors out of business in Utah. Senate bill No. 39 provides that if an "improvement" is estimated to cost less than $15,000 for a city of the first class, or less than $10,000 for a city of the second class, the city need not call for bids at all on the work, but may do it by day labor. If the estimated cost of the work exceeds these amounts, it must be advertised; but if the lowest bid exceeds the engineer's estimate, then the work may be done by day labor.

Obviously these provisions are such that all work may be done by day labor by adopting either one of two schemes. A large job can be divided into sections of less than $10,000 each and each section can be regarded as a single "improvement," thus making it possible to do the entire work by day labor. Any job, however large, can be done by day labor, provided the engineer estimates its cost so low that no contractor can bid within the estimate. Such an underestimate would not often occur intentionally, for very few engineers are dishonest; but underestimates are constantly being made by engineers because of lack of knowledge of all the cost items involved in construction. Then, if bill No. 39 were a law, every time that an engineer erred in his estimate the work would perforce be done by day labor!

As for the taxpayer, who would guarantee him that the engineer's estimate was correct? Certainly not the engineer, nor any building company. The taxpayer would simply foot the bill, as he now does for sewer work in Detroit.

Into this nice mess the municipalities of America are drifting, and we fear they are more than drifting—they are being towed there vigorously by all the forces of labor unionism and socialism and ignorant reformers combined.

It is high time that public works contractors bestir themselves. In those cities where construction work is now being done by day labor contractors should start propaganda that will lead to the keeping of detailed cost records. The records should be audited and analyzed by competent engineers who are not personally interested in proving that the costs are low, but who are seeking to show the exact cost and the whole cost per unit of work done. We do not know of a single city in which such disinterested engineering auditing of cost accounts is regularly made, yet without such an audit the costs that are published in reports are almost invariably partial costs.

Many a city department prides itself on doing construction work at less than contract prices, when even casual study of the cost accounts discloses omission after omission of essential items, such as interest and depreciation of equipment, taxes lost to the city on the same, failure to charge against a job the time of salaried employes when not actually on the job, as during idle seasons, holidays, etc., etc.

Any city department that rebels against periodic audits of its cost accounting discloses by its very rebellion that it is not certain of the correctness of its accounting. Hence no honest opposition can come from city departments when it is proposed that their work be subject to outside audit at regular intervals.

Not only should every contractor in Utah join the "Contractors' Temporary Organization," of which E. W. Ryberg of Salt Lake City is chairman, but a permanent state society should be formed. Then that society should affiliate with other similar societies, such as the Illinois and the Wisconsin Municipal Contractors' Associations, thus building up a national organization of public works contractors.

We shall welcome suggestions from our readers relative to this very important matter.

SHOULD NOT THE QUESTION OF UNIVERSAL MILITARY SERVICE BE ANSWERED BY COST DATA?

To engineers it is remarkable that no cost data have ever been published to indicate whether it would be cheaper for the United States to secure protection from the disasters of war by means of a navy, or by an army, or by a definitely stated combination of these two arms of defense. There are those that contend that our policy should be that of Great Britain, a purely naval policy in times of peace. And there are those that call for universal military training like that of Germany, a policy of preparedness on land. But who has ever calculated the costs of each of these policies, as applied to America, and thence derived an economic answer?

To illustrate how such a problem should be solved, let us assume two sets of data; one set of data for a large navy, adequate to protect us against any power for a period of two years, during which an army could be trained and equipped; and the other set of data for a small navy backed by trained citizens ready to take up arms, of whom half a million are constantly in arms, undergoing training.

FIRST PLAN—LARGE NAVY.

Investment in navy	$1,500,000,000
Annual repairs, 1 per cent	$ 15,000,000
Annual depreciation, 6 per cent	90,000,000
Annual interest, 4 per cent	60,000,000
Total annual plant charges	$ 165,000,000
Crew, 200,000 men at $1,000	200,000,000
Fuel, etc.	15,000,000
Explosives, etc.	20,000,000
Total annual cost of first plan	$ 400,000,000

SECOND PLAN—LARGE ARMY AND SMALL NAVY.

Investment in small navy	$ 500,000,000
Investment in army equipment for 2,000,000 men at $1,000	2,000,000,000
Total investment	$2,500,000,000
Annual plant charges, 10 per cent	250,000,000
Operating expenses of navy	80,000,000
Operating expenses of army, 500,000 men at $1,000	500,000,000
Total annual cost of second plan	$ 830,000,000

While the foregoing costs are merely illustrative, they are significant even as they stand. If they are approximately correct—and we believe they are—these figures demonstrate that America would be economically foolish to choose universal military training instead of a large navy as its preferable means of protection.

Although men for military or naval service can be hired at much less than $1,000 per man per annum, inclusive of their food, and although they can be forced to work without pay, it remains a fact that able-bodied men in America are capable of earning $1,000 a year, on the average. Hence the annual loss of income while in military duty becomes the true criterion of the value assignable to their services in such a calculation as the above.

Before America is committed to any definite policy as to universal military service, should we not have before us a very carefully calculated statement of all the costs that enter the problem? Certainly this is the step that an engineer would take. Is this not, in fact, a mighty engineering problem, in which the end sought is the most economic means of protecting American lives and property from predatory nations? If so, is it not time to call a halt on the wordy debates that are already in progress and secure an engineering study of this whole economic problem before a decision is reached?

"COAL STRIPPING AND THE CONTRACTOR."

Under this caption our interesting contemporary, the Excavating Engineer, states that there is a rapidly growing field for contractors in stripping coal beds with big revolving shovels. As evidence of this fact, it is stated the Bucyrus Co. alone has sold within the last six months 18 coal stripping shovels of the revolving type, ranging from 160 to 312 tons in weight.

Dirt moving contractors will certainly do well to investigate the possibilities in this field.

In our last excavating monthly issue, Jan. 17, we published a very interesting article on stripping anthracite beds in Pennsylvania, but that article described the use of smaller shovels (60 to 70 tons) that loaded cars.

The Excavating Engineer gives a remarkable record for one 320-ton revolving shovel in Missouri. It is equipped with an 80-ft. boom and a 6-yd. dipper that holds nearly 8 yd. heaped up. It excavates two buckets a minute, and on a three-day test it dug 6,038 cu. yd. per 9-hour day. The shovel has been averaging 4,500 yd. per 9-hour day, in a cut 10 to 28 ft. deep, consisting of sandy clay with occasional ledges (10 to 18 in.) of shale and sandstone. The plant is owned and operated by the Sherwood-Lester Coal Co., Liberal, Mo. The shovel crew consists of one engineman, one craneman, one fireman and four pitmen. A shovel of this size will dump 100 ft. from the center of the turntable and 62 ft. above the surface of the coal bed on which it rests, handling an overburden 40 ft. deep. In this instance the coal bed is only 28 in. thick. A few years ago such a coal bed would have been regarded as worthless, but progress in the "art of dirt moving" now renders it profitable to mine a bed of this thickness.

In opening up a coal bed like this, the shovel digs its way down to the coal on a 10 per cent grade, making the "box pit," which may be 65 ft. wide and 30 ft. deep. The stripping is all dumped on one side of the pit. Then after the coal is removed from the "box pit" the shovel makes another parallel cut, dumping the stripping into the "box pit," and so on, handling the stripping but once.

In this instance the coal is "mined" and loaded by hand into tram cars that are hauled by a 10-ton Davenport locomotive to the tipple, 800 tons of coal being mined per day of 8 hours.

The foregoing outline suffices to give a pretty clear idea of the economic possibilities of mining coal by the open cut method, with the aid of very large shovels designed especially for this purpose.

THE COST OF THE ROGERS PASS TUNNEL

The 5-mile Rogers Pass tunnel on the Canadian Pacific Ry. was recently completed at a cost said to be $6,500,000, or nearly $250 per foot. The costs of the two tunnels through the Cascades in Washington, one on the Northern Pacific and one on the Great Northern, were each about $180 per foot, including masonry lining; but neither of these tunnels was more than half as long as the Rogers Pass tunnel. The contract for this tunnel was let on June, 1913, a 3½-year construction period being specified. The tunnel was finished 11 months ahead of the contract time. The tunnel drifts were started in June, 1914. The east pioneer tunnel heading was started in September, 1913, and the west pioneer heading the latter part of May, 1914.

In order to increase speed and facilitate ventilation and haulage, a small pioneer tunnel was driven in advance of the main Rogers Pass tunnel and parallel thereto. Although this materially increased progress, it seems to have added considerably to the construction cost.

The construction cost, however, is not the only criterion of relative economy. The interest charges during construction amount to a very respectable figure on a long tunnel. In addition, since a tunnel of this sort is usually built to reduce operating expenses, there is the item of excess operating expense that is incurred every day that the tunnel remains uncompleted.

EDITORIAL COMMENT.

The United Improvement Federation of Los Angeles proposes to amend the city charter so as to make it illegal to let contracts for pavements or other city work. The "municipal ownership bug" has apparently stung L. A. so badly that some of its citizens have become bereft of all reason.

During the five years in which road work has been in progress in Wisconsin under the state aid law, 4,846 miles of road have been graded, requiring 10,300,000 cu. yds. of earth excavation. This amount was spread over 6,327 separate road jobs, which gives an average of about 1,600 cu. yds. per job.

The U. S. Reclamation Service is now calling for bids on the largest earth moving job it has advertised so far this year. The work calls for 2,227,000 cu. yds. of excavation from the Fort Laramie canal of the North Platte Project. It is located near Fort Laramie, Torrington and Lingle, Wyo., on the C., B. & Q. Ry. The bids are to be opened March 15.

The digging of 30,000,000 yds. of earth for 300 miles of ditches and 54 miles of levees is soon to be advertised for letting. This work will be done to drain 300,000 acres in Arkansas. The plans have been drawn by the Morgan Engineering Co., Memphis, Tenn., and the assessments on the property in the drainage district are now being computed.

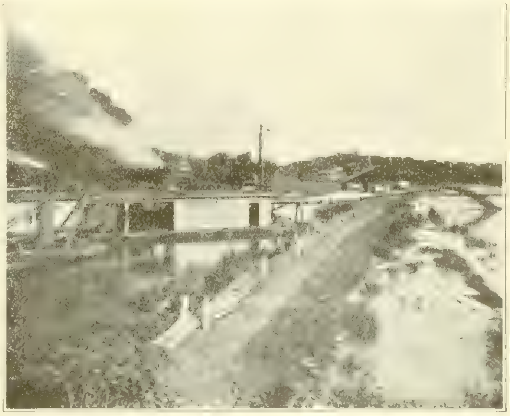
The work will be divided into several contract sections. The construction period is to be about three years.

A very welcome "swallow" is this harbinger of what promises to be a prosperous spring for dirt movers.

BRUSH FENCE FOR RETAINING SPOIL FROM HYDRAULIC DREDGE.

In connection with the deepening of the Galena River by a hydraulic suction dredge, a brush fence was built to retain the spoil. The methods employed in constructing this fence are described by Captain S. Edwards, U. S. assistant engineer, in the January Iowa Engineer, from which the following notes are taken.

Fascines made of small willows 1 to 2 in. in diameter, bound into bundles 16 to 20 ft. long and 12 in. to 15 in. in diameter, tied with wire or lath yarn were used. From 400 to 600 cu. yd. of these fascines were loaded on a barge, the cost averaging about 22½ ct. per cubic yard on the barge. Willow trees 6-in. to 8-in. diameter along the pool shore were cut down and made into stakes about 6 ft. long. A good supply of stakes on hand were loaded on a small handy barge. The stakes were driven in two rows, longitudinally 6 ft. apart and transversely 18 in. This was done by a force of 4 to 6 men. When they had finished putting the stakes in place they carried the fascines ashore from the brush barge, and dumped them between the stakes one on top of the other and overlapping. For greater stability, the top of the stakes were wired together. About ⅓ cu. yd. of willows was used per lineal foot of fence.



View of Suction Dredge and Section of Brush Retaining Fence.

To avoid leakage through the fence and also to add to the stability, a backing of dirt was thrown up against the brush fence. One man could easily cover a distance of 300 or 400 lin. ft. per day.

This completed, the suction dredge was put in place. The discharge pipe was so suspended from the dredge that no handling by man power was necessary. The dredge could thus move more freely and advance without the usual delay of moving the discharge pipe by hand. The suction pipe is attached to a double pontoon with a swing of 180° and a radius of about 45 ft. After each sweep the dredge moves forward 3 ft.

Owing to the soft nature of the deposit, a cut 2x4 ft. deep is made in one sweep; only in exceptional cases is it necessary to reduce the depth of cut and make a second sweep. A powerful winch with cables to the outer end of the pontoon pulls the suction intake through the mud while a 12-in. rotary pump sucks it up and forces it out of the discharge pipe. Because of the soft nature of the material no cutter is required on the suction head.

The retaining fence has proven a success. Whenever possible the opening for the discharge of the water, generally an old piece of dredge pipe, is put in either end of the ground enclosed, the one farthest away from the discharge pipe being left open. About ¾ of a mile from the discharge the water will return to the pool practically clear, the spoil having settled. In cases where it is not possible to arrange so long a travel for the flow, a few fascines of willows are thrown on the ground at a right angle to the fence and touching the backing so as to compel the water to take the zig-zag course increasing the length of travel.

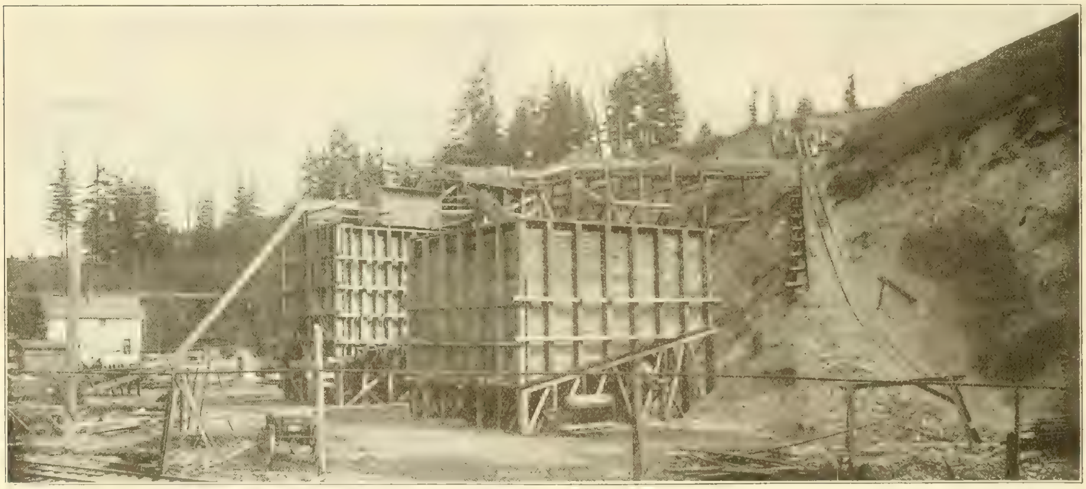
A GRAVEL AND SAND PLANT OPERATED BY WATER AND ELECTRICITY.

Contributed by E. C. Willard.

The gravel producing arrangement described in this article does not possess any surprisingly new features, but it may serve to point out certain methods that may be of value to those interested in the economical handling of material.

This plant is located in a western city. The sand and gravel are excavated by water and carried by water to the screens.

The water is brought to the plant by means of a flume running back to a creek. This flume is built of 2-in. lumber and measures 24 in. by 20 in. The length of the flume is about 1,300 ft., and it is supported upon timber bents spaced about 20 ft. from each other. Close to the bunker or bin there is a 4-in. pipe leading from the flume and it is connected to a 2-in. pipe. A hose can easily be attached to the end of the smaller pipe, and, as there is a head of about 20 ft. at this point, there is sufficient power to wash the sand and gravel from the face of the pits into the troughs.



General Arrangement of Gravel and Sand Plant.

The troughs or sluices are built in the ground, of 2-in. lumber, and measure about 15 in. wide by 8 in. deep. They extend to the face of the pit and lead to the bunkers. At one of the bunkers there is an endless bucket conveyor, motor driven, which picks up the material and carries it up and empties it into an inclined trough that delivers to the screen. The screen is a trough whose sides flare apart and whose bottom consists of 1-in. rods, which of course are nearer together at the point of the V than at the upper end. The material is here screened into various sizes of stone and sand. The gravel is discharged into two chutes, one on each side of the bin, which are arranged so that either or both of them may be shut off. One of these leads to a second bunker where the large stones are run through a crusher, and then by means of another endless bucket conveyor are carried to a third bunker where the broken stone is again screened and distributed into two different classes. The screen here is the common cylindrical pattern, the smaller mesh being ¾ in. and the larger 1½ in.

After separating the stone and the sand, the sand passes over a screen with a 3/16-in. mesh, the finer portion being sifted out and passing by means of another trough, directly into the storage bunker bins. The larger material falling out at each side upon two screens of coarser mesh is screened again and carried directly to the bins by troughs. The water itself runs directly into the creek through a trough. The foregoing description relates to plant No. 1.

The photograph shows the general arrangement of plant No. 2. From the bunkers of this plant there is an inclined trough leading up the hill. At the head of the trough the sand and gravel are washed out by water which is forced up from below through a 4-in. pipe by a pump located in the shed just at the left in the photograph.

The sand and gravel are carried along by the water to the cylindrical screen at the top of the bunker, which is also motor driven and which separates the material into three classes. Surplus water is then carried away through a trough to the creek. There is an inclined railway up which the gravel cars are pulled to the top of the hill by a motor driven cable. This allows for excavation below the bunkers, and the cars in this plant take the place of the bucket conveyor in plant No. 1.

As can readily be seen, both of these plants are capable of economical operation, and only a few men are necessary for the operation of the plant. The track of the local street railway system passes directly in front of the plant and a spur leads to the bunkers so that the material is easily delivered to the market.

Below are given a few approximate operating costs for one year:

	Cents per Cu. Yd.
Electric power	5.5
Labor	8.1
Total	13.6

No pit rent, interest, taxes or depreciation are figured in this cost. The approximate number of yards handled during the year were 14,000 cu. yd.

The use of water for excavating and conveying sand and gravel is very common on the Pacific Coast. There are many pits in other parts of the country where this method can be adopted. One of the incidental advantages is that the water thoroughly washes the sand.

The Public Service Commission for the First District, New York City, has approved the form of contract upon which the Interborough Rapid Transit Co. will ask for bids for 310 new steel cars for use in the new subways and subway extensions to be operated by it. The contract will shortly be advertised. It contains provision by which the Interborough may exercise an option for the purchase of 167 more cars. The Interborough has already purchased more than 300 cars for the new operation and will eventually order another 300.

SOME CONSTRUCTION FEATURES OF A 500,000-BBL. OIL STORAGE RESERVOIR.

A back-filling machine was used for trimming down the slopes of an oil storage reservoir constructed recently at El Segundo, Cal., for the Standard Oil Co. The reservoir has a capacity of 500,000 bbl., and is approximately 400 ft. in diameter at the floor line with wall slopes of 1 to 1½. The depth at the center is 22 ft. and the depth at walls is 19 ft. The concrete floor is 4 in. thick, and the concrete surface for the walls is 2½ in. at the top and 3½ in. at the base. Both walls and floor are reinforced with one layer of 6x6—6/6 Clinton fabric. The columns and roof are of Oregon fir. The roof is finished with 1-in. sheeting covered with Johns-Manville asbestos roofing.

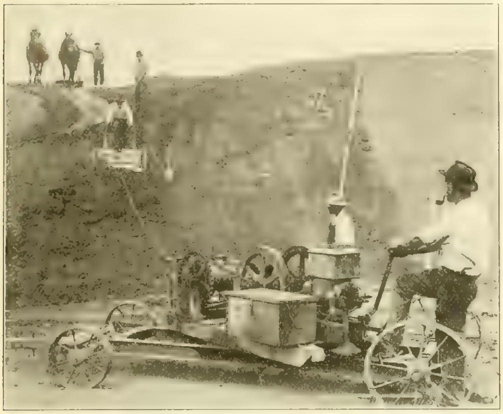


Fig. 1—Trimming Down Reservoir Walls With Back Filler.

The reservoir is located on rolling ground, the site selected being a natural basin. The excavation in the bottom of this basin ran from a minimum of 2 ft. in the center to 8 or 10 ft. at the wall, and the excavated material was used to make embankment to give a greater height of wall.

Fig. 2—Laying Concrete Floor of El Segundo Reservoir.

The embankment was sprinkled and rolled with petrolithic rollers, beside being compacted more or less by the teams and wheel scrapers, and even though the soil was a light sandy loam, the contractor succeeded in making a very hard, solid bank against which to place the concrete. The floor also was excavated 2 ft. below finished grade and refilled in order to compact that portion of the work in the same manner that the banks were treated.

In making embankment, the banks were over-filled approximately 15 in. and trimmed down to hard surface before concreting. The heavier part of this trimming was done with a Waterloo backfiller as shown in Fig. 1. The final finish trimming was done by hand.

The Standard Oil Co. furnished all material. Bent Bros. Construction Co. performed the work.

CLEARING AND GRUBBING METHODS.

The land clearing demonstration trains operated during 1916 by the Agricultural Engineering Department of the Wisconsin College of Agriculture developed certain methods of clearing and grubbing which, it is believed, will be of service to contractors. A description of this method was given by Prof. C. D. Livingston in a paper presented at the recent road school of the University of Wisconsin. Extracts from this paper follow.

Burning is the usual method of disposing of the stumps. The pieces, therefore, should not be too large, they must be free from dirt, reasonably dry, and the piles should be high, narrow and compact. In order to bring this condition about, a combination method of using horse pullers, low grade dynamite, and horse pilers will probably serve the purpose better, in a majority of cases, then the methods now in general use.

Horse power pullers are at present being looked upon with favor because the manufacturer has developed accessories which greatly add to the efficiency of their product. Dynamite is used to break up the big stumps, and serviceable pilers have been developed for use in connection with them.

Stump pullers are now made of cast steel instead of iron. This construction gives greater strength with less weight. It is very easy to haul the entire equipment from one place to another as the pullers may be equipped with demountable wheels. They are manufactured in different sizes to meet the requirements of various conditions of stumps, soil and finance.

More development has been made along the invention of accessories. The introduction of such new devices as take-ups and power pulleys has done much to increase the popularity of the puller. A take-up is an ingenious contrivance which enables the operator to connect a stump to any point on the main line. It is not heavy, is serviceable, and doubles the speed of clearing. While the first stump is being pulled, a second take-up is being fastened to a second stump. As soon as the first stump is out the first take-up is snapped from the main line and connected to the second. Little time is lost, for, as the second stump comes out, the operator unhooks the first take-up and places it about the third stump in readiness to be fastened to the main line as soon as it is free of its last hold.

Power pulleys allow the energy at the machine to be multiplied and this enables the outfit to be constructed of lighter materials. By using these pulleys, a powerful force can be exerted at the stump to be pulled, and it has been found that multiplying the power four times in a quadruple pull, will tip out all but the very largest stumps.

When the stump is out, split it up with low grade dynamite. The reasons for adopting this method are: It takes no longer to pull a whole stump at once by a power pull than to crack it first and make several straight pulls. All the roots are out and after dynamite has been used they are much more free from dirt than if the stump had been shot before pulling. The same amount of dynamite will leave the pieces more free from dirt and in better condition for burning when the stump is cracked afterwards.

The proper place to get the charge is right against the crown of the stump on the root side, just at the point where all the roots join. It is not necessary to bore into the stump but merely to get the charge at the proper place and then tamp it well with a stiff mud. Twenty per cent, low freezing ammonia dynamite, sometimes known as farm powder, is even better adapted for cracking than the higher grades. The action of the low grade dynamite is a shaking one, rather than the cutting action of the high explosives. It is also much cheaper.

Dynamite, of course, plays a very important part in all land clearing operations and there is manufactured a kind of dynamite for every use. Very often a lower grade dynamite which is cheaper would do the work even better than a higher priced article. The proper grade can be determined by trial or experience.

Generally speaking, the cheaper, low grade dynamite can be used on the heavier soils like the clays, silts and loams. This is especially true if the ground is wet or damp. As the soil becomes lighter or drier the percentage used must be increased until on the lightest and driest of sands 60 per cent straight nitroglycerine dynamite is needed. For general use in land clearing, 20 per cent, 30 per cent, and 40 per cent are best adapted.

Getting the charges of dynamite where they will do the best work is a very important part of stump blasting. If the load is placed too high, the dirt may be blown from between the roots or the stump only cracked. If the load was large enough to take the stump out, many of the roots surely must be cut off and left to interfere with the work of the grading gang. It is far better practice to use a slow dynamite and load deeper. Such a method will bring out all the roots and still break up the stump.

In blasting any stump the charge or charges must be placed where the roots are holding the tightest. With the cap and fuse method of firing, only one charge can be placed and that, under the center of resistance. But if electrical blasting is used a charge can be spread under a number of the larger roots and all loads exploded at the same time. This method of firing makes it possible to get the dynamite where it is most needed.

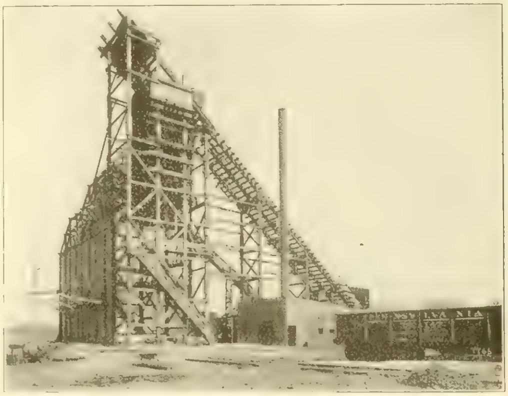
Some operators remove the wrappers from the cartridge so the dynamite can be packed in order to completely fill the hole. This is poor practice as the dynamite may become moist and therefore wasted. Dirt will also mix with the free dynamite, which decreases its efficiency. A good way is to slit the wrapper three or four times the long way. When tamped the cartridge spreads to fill the bore hole. No dirt is mixed with it.

Getting the stumps on top of the ground is only half the story. They must be burned and that means getting them into a pile. Mechanical pilers of the boom type, however, accomplish this work about as satisfactorily as any method. A home-made one will do the work nearly as cheaply as will the higher priced ones. An automatic trip at the other end of the boom is a valuable asset as it allows piling and burning to be carried on at the same time. This means that stumps can be burned when more dirt is on the roots and when more water is in them than by piling first and burning afterwards. Green stumps, or those with dirt on the roots need to be continually jarred or they will not burn completely. Fresh stumps added to the pile at regular intervals serve this purpose. A piler makes a stump puller more efficient and larger pieces can be handled, which means a saving in dynamite.

SAND AND GRAVEL PLANT WITH SKIP HOIST ARRANGEMENT.

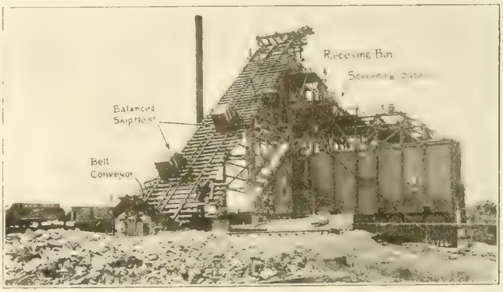
A good illustration of a high-capacity, fool-proof sand and gravel washing and screening plant, which requires few men for its operation, is shown by the installation of the Penn Sand & Gravel Co., Tulleytown, Pa. This plant was designed and built by the Link-Belt Co., Philadelphia.

The material is brought to the plant by means of 2-yd. cars loaded by a drag line excavator, the cars dumping into a large track hopper, which delivers through a gate to either of two skip hoists, of 4½ cu. yd. capacity each. These run alternately to the top of the incline, and dump into a large bin at the top of the plant. From this bin material is flumed by means of jets of water to three sets of "Gilbert" type conical screens, which deliver the various sizes of gravel to the bins. The sand and water are separated by a series of three counterweighted separators at the sand partition end of the bin, and the water is flumed away to a nearby field.



Plant of Penn Sand & Gravel Co., Tulleytown, Pa.

The rejections from a bar screen in the hopper at the top of the plant are chuted back to a pair of Symons' crushers, where the oversize is crushed and delivered by means of an inclined belt conveyor back to the original dump hopper, and in this way re-elevated by means of the skip hoists, and carried up to the bins.



View Showing Counter-balanced Skip Hoist Arrangement.

This plant has a capacity of over 1,000 yd. per day, and the skip hoists are capable of handling twice this quantity, should another bin and set of screens be added on the opposite side of the skip way.

The water is delivered to the screens and bins under the skip hoist by means of a 2-stage centrifugal pump, against a total head of about 90 ft., and the screens are driven by means of a light rope drive from the engine room located on the ground. The use of the counter-balance skip hoist arrangement requires power for raising the gravel only, as one skip balances the other. The large bins at the top of the plant delivering to the screens insures a uniform delivery or stream of material to the three sets of screens, which keeps them working well below their rated capacity, without the necessity of operating them intermittently at overloads and light.

Delivery to railroad cars is made from either side of the bin, and the cars are pulled along the track by means of a winch and wire cable, doing away with the necessity of shifting by locomotive, thus making the plant independent of railroad shifting engines.

COMPACT GRAVEL DIGGING PLANT FOR CONCRETE BRIDGE CONSTRUCTION.

A compact gravel digging outfit is being used by the Hackedorn Contracting Co., Indianapolis, Ind., for securing material from the river bed for use in the construction of the 5th St. bridge at Dayton, O. The installation consists of a 700-ft. dragline cableway equipped with a 1-yd. "Pioneer" excavator bucket operated by a 40-H.P. Lambert double-drum hoisting engine. The mast of the cableway is seen just behind the concrete distributing tower in the illustration. The "dead man" on the opposite bank of the river can be moved so that the excavator can cover a wide radius within 500 ft. of the dumping point.

Gravel Plant and Concrete Tower at 5th St. Bridge.

The bucket dumps on a grizzly bar which separates the boulders from the gravel, the latter dropping through the bars and passing through a "Gilbert" screen which washes and separates the sand and gravel. The gravel passes out of the screen down one chute into a 250-yd. bin and the sand is chuted from the sand-settling tank into an adjoining 150-yd. bin. An interesting feature related by Edward Hughes, superintending engineer for the Hackedorn Contracting Co., is that the run of a bucket of sand and gravel as it comes from the river is almost the exact proportions required for the mix. This is indicated by the rate at which the two bins maintain proportionate quantities of the materials.

Under the bins is the mixer, a 30-ft. motor-driven "Koehring," and a few yards away is the cement house. A track runs to the cement house and the hoist that operates the Insley concrete bucket in the tower also hauls the cement cars.

The main tower of the Insley concrete distributing plant is 175 ft. high and distributes concrete to the forms for five arches and five pier abutments. From an auxiliary tower 100 ft. high run the chutes for the remaining pier abutment and two arches of this 700-ft. bridge. With this plant arrangement an average output of 350 cu. yd. of concrete a day is obtained.

COST OF LOADING ORE WITH STEAM SHOVELS.

At the Santa Rita, N. Mex., mines of the Chino Copper Co. the ore and waste, broken by blasting, are loaded onto cars by Marion steam shovels. Data on the cost of this work are given in a recently issued bulletin of the U. S. Bureau of Mines, from which the following notes are taken. The investigations on which the bulletin is based were made in 1914.

Of the shovels, there are six of the 91-ton model, two of the 92-ton model, one of the 100-ton model, and one of the 40-ton model—ten in all.

The 40-ton and the 100-ton shovels are used for digging first or pioneer cuts, also called "thorough" cuts. The 40-ton machine has a large arc of swing to its boom, so that it can carry a cut into a bank, swinging its dipper back to one side far enough to dump into a car close to the side of the shovel and back from the working face of the cut. The other shovels when making first, or pioneer cuts, have to load onto cars that stand on the bank above, outside the excavation that is being made. The 91-ton and the 92-ton shovels are designed to have a maximum lift of 19 and 21½ ft., respectively; hence, in general, they can not make a first cut more than 10 to 12 ft. below the level of the loading track. The 100-ton shovel, however, is built with a long boom and dipper arm, so that it has a maximum lift of 35 ft. Its function is primarily to make pioneer or "thorough" cuts, which the other shovels enlarge. It can cut a wide ditch about 22 ft. deep, lifting the material up onto cars that stand on the banks outside the cut. It has a dipper with a capacity of 3 cu. yd., whereas the capacity of the 91-ton and of the 92-ton shovels is 3½ cu. yd. This smaller dipper is necessary because the longer boom and dipper arm—92-ft. extreme radius—greatly increases the strain on the machinery.

The crew of each shovel consists of an engineer at $190 per month, a craneman at $135 per month, a fireman at $3.50 per 10-hour shift, an oiler at $2.25 per shift, and 6 to 8 pitmen at $2.25 per 10-hour shift, who assist in loading operations and in moving the shovel.

The material handled per day of two 10-hour shifts by each shovel, except the small 40-ton machine, is 1,400 to 2,800 cu. yd., measured in the solid. This rather wide variation is due to occasional shortage of cars, local difficulties of digging, or temporary breakdowns.

The coal, oil, and cotton waste used per 10-hour shift is as follows:

	Amount used by different sized shovels		
Material.	40-ton.	91-ton and 92-ton.	100-ton.
Black oil	[illegible] quarts	[illegible] quarts	2 quarts
Cylinder oil	[illegible] pints	[illegible] quarts	1½ gallon
Engine oil	[illegible] pint	[illegible] pint	1 pint.
Crude oil	1 quart	2 quarts	1½ gallons
Cup grease	½ pound	[illegible] pound	½ pound
White cotton waste	1 pound	1 pound	1 pound
Run-of-mine coal	[illegible] tons	[illegible] tons	7½ ton

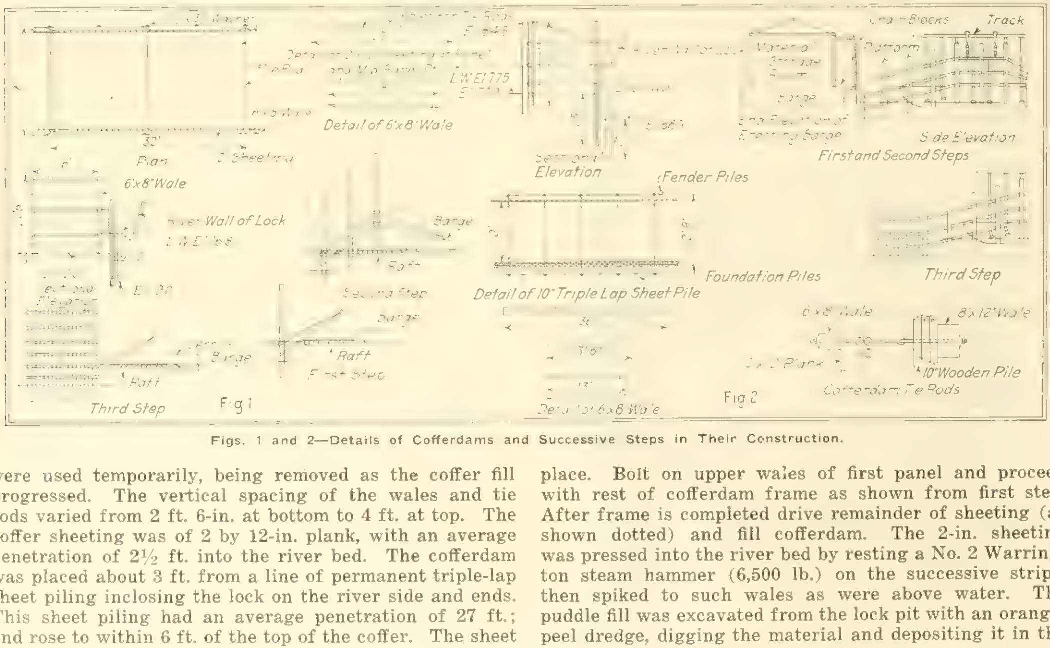
Heavy castings and repair parts for all the shovels are kept on hand so that a shovel can, without much delay, be almost rebuilt in the company's machine shops.

The cost of loading is, in general, 6 to 12 ct. per ton. In a few cases, owing to exceptionally unfavorable circumstances, the loading costs for one shovel for a month have averaged as high as 29 ct. per ton. On the other hand, exceptionally favorable conditions have at times reduced the monthly average to a little more than 4 ct. per ton.

METHODS AND COST OF CONSTRUCTING BOX COFFERDAMS.

In the construction of Lock and Dam No. 3 on the Ouachita River, Louisiana, in 1913 by the U. S. government, a box cofferdam was built to inclose the lock. A modified type of box cofferdam was employed in the following year in the construction of the lock and dam in the Big Sunflower River, Mississippi. In the January-February Professional Memoirs of the U. S. Corps of Engineers, Mr. T. C. Thomas, U. S. assistant engineer, describes the methods employed in the construction of these cofferdams and gives the cost figures. He also presents comparative data on these box coffers and the puddle wall type. The matter following is taken from Mr. Thomas' article:

The box cofferdam at Lock No. 3, near Riverton, La., was 19 ft. in height for the greater part of its length, placing its top at an elevation corresponding approximately to a 14-ft. river stage. The puddle fill, a clayey sand, was 16 ft. thick. The underlying material varied from a clayey sand at the surface, through clean sand and a sand and gravel mix, to blue clay at something over 30 ft. below the river bed. The coffer framing consisted of six lines of 6 by 8-in. waling with 2 by 12-in. verticals, and 1-in. tie rods at 8-ft. centers horizontally; three lines of 4 by 4-in. horizontal struts on same centers as the tie rods were used temporarily, being removed as the coffer fill progressed. The vertical spacing of the wales and tie rods varied from 2 ft. 6-in. at bottom to 4 ft. at top. The coffer sheeting was of 2 by 12-in. plank, with an average penetration of 2½ ft. into the river bed. The cofferdam was placed about 3 ft. from a line of permanent triple-lap sheet piling inclosing the lock on the river side and ends. This sheet piling had an average penetration of 27 ft.; and rose to within 6 ft. of the top of the coffer. The sheet piling paralleling the river wall of the lock was to be cut off at low-water mark after the removal of the cofferdam, but a stage sufficiently low for the purpose has not occurred since the taking out of that structure, in December, 1914.



Figs. 1 and 2—Details of Cofferdams and Successive Steps in Their Construction.

The sheet piling across the ends of the lock was removed, down to the lock floor, in December, 1914. The triple-lap piling, below the final cut-off, is in contact with the concrete, to which it is anchored at 1-ft. intervals horizontally, and forms a part of the permanent lock construction. No special effort was made to fill the space between the triple-lap piling and the coffer, but in the process of filling the coffer with material excavated from the lock pit, this space was filled nearly to the top of the piling with droppings from the dredge buckets. The tripple-lap piling, and the earth seal between it and the coffer, should be considered as a part of that structure, or as supplementing it, taking the place of the outside and inside embankments generally used. Details of the cofferdam are shown in Fig. 1.

The upstream end and river side of the cofferdam was placed during August and the early part of September, 1913. Operations were suspended in middle September, 1913, on account of unusually high water, and not resumed until October, 1914; the coffer being completed from the 15th to the 20th of that month. Before the cofferdam was submerged in 1913, round fender piles were driven at 20-ft. intervals along the outside wall, and 53 cu. yd. of light riprap were deposited around the upper outstream corner, as a protection against scour.

The coffer skeleton, consisting of 2 by 12-in. sheeting bolted to the waling at 8-ft. intervals, was assembled on a raft and barge, and launched by supporting the successive panels with a derrick while the raft was moved back to clear, then lowering the framing to place. The details of the process are shown in Fig. 1. Referring to this illustration the successive steps were: First step: Bore 2x12-in. sheeting and 6x8-in. wales. Bolt two lower wales to sheeting with tie rods and spacers. Set and drive sheeting with derrick, allowing waling to rest on operating raft. Second step: Move operating raft clear of mid panel bolt holes and fix sheeting to middle and free ends of waling. Fix two lower wales of next panel. Third step: Move operating raft clear of panel, supporting panel with derrick meanwhile. Set and drive panel in place. Bolt on upper wales of first panel and proceed with rest of cofferdam frame as shown from first step. After frame is completed drive remainder of sheeting (as shown dotted) and fill cofferdam. The 2-in. sheeting was pressed into the river bed by resting a No. 2 Warrington steam hammer (6,500 lb.) on the successive strips, then spiked to such wales as were above water. The puddle fill was excavated from the lock pit with an orange-peel dredge, digging the material and depositing it in the coffer with one handling.

The coffer skeleton, 640 ft. in length, was placed in 24 working days, the sheeting in the same number of such days; the two classes of work overlapping as far as practicable. The greatest length of coffer framing placed in one day was 48 ft.

From middle September to December, 1913, there was a scour of from 2 to 3 ft. along the outside of the coffer, increasing to 5 ft. at from 20 to 40 ft. out; and at the beginning of the following working season the structure was found to be in an unsatisfactory condition. The following is quoted from the report of operations at Lock and Dam No. 3 for the month of October, 1914:

> The part of the cofferdam which was built last year has been undermined and is tending to slide out into the river. This has been stopped to some extent by the anchoring of the cofferdam to the permanent sheet piling with 1¼-in. rods. This seems to hold the top, but the bottom has gone out into the river about 2 ft. The cofferdam will not hold over a 5-ft. stage in its present condition.

Work was prosecuted inside the cofferdam from latter part of October until early December, 1914, in which time the river wall was concreted to about half height, furnishing support to the triple-lap sheet piling and the adjacent cofferdam, and a floor section at downstream end of lock was placed. December 1 a sharp rise set in and work inside the cofferdam was abandoned on the 9th, when the river stage was practically 9 ft., and the head on the bottom of the excavation immediately inside the sheet piling at the ends of the lock was about 17 ft. Under the final conditions, the percolation, which was confined largely to the ends of the lock pit, reached the capacity of the 8-in. centrifugal pump installed for unwatering the cofferdam, and the top of the triple-lap sheet piling, where not supported by concrete, was forced inward—in some places as much as 3 ft.

The work had progressed, however, to a stage where the river wall could be used as part of a cofferdam, leaving only the ends to be closed, to enable the lock pit to be unwatered and the work completed. The box cofferdam was taken out in December, 1914, and the lock ends closed by a "puddle-wall" cofferdam in 1915.

The labor forces employed in building the cofferdam, puddling excepted, with the corresponding cost of services and subsistence, were as follows:

PLACING COFFER FRAMING.

1 foreman, at $3.00	$ 3.00
1 engineman, at $2.50	2.50
1 stoker, at $1.50	1.50
18 laborers, at $1.65 each	29.70
	$36.70
21 rations at $0.50 each	10.50
Total cost per day	$47.20

PLACING COFFER SHEETING.

1 foreman, at $3.00	$ 3.00
1 engineman, at $2.50	2.50
1 stoker, at $1.50	1.50
9 laborers, at $1.85	16.65
	$23.65
12 rations, at $0.50 each	6.00
Total cost per day	$29.65

The puddle fill was placed by the usual force for an orange-peel or clam-shell dredge. A statement of the cost of the cofferdam is given in Tables I and II.

At the Big Sunflower River Lock, Little Callao Landing, Miss., there was used a modified box cofferdam; the inner wall consisting of deeply driven triple-lap sheet piling, the outer wall being of the usual box construction. The height of the cofferdam was between 11 and 12 ft., and the top, at the outer wall, was at an elevation corresponding to a 7-ft. river stage. The puddle fill, a clayey sand, was 10 ft. thick. The underlying material varied from a comparatively shallow stratum of sandy clay at the surface, through clayey sand and pure sand, to sand and gravel at about 30 ft. below the river bed.

The triple-lap sheet piles were built of 3 by 12-in. planks with 4 by 12-in. planks between. This piling was driven to an average penetration of 26 ft.; and the portion below the final cut-off, at low-water mark, was left as part of the permanent construction, being in contact with the lock concrete and anchored thereto. The waling of the outer wall consisted of 6 by 8-in. timbers arranged in three raws. The sheeting was composed for the most part of 3 by 12-in. planks, although some 2-in. stuff was used. The coffer walls were tied together with a jointed system of eye-bolts, shackles and eye-rods, to facilitate the placing of the coffer framing. Details of the structure are shown in Fig. 2 The successive steps (see Fig. 2) in constructing the coffer were:

First step: In driving triple-lap sheet piles, place tie rods in each sixth pile, when 1¼-in. hole passes guide wale place 8 by 12-in. 4-ft. wale, holding wale in place with eyebolt attached to tie rod. Second steps: Erect panels on platform of erecting barge, by bolting wales to sheeting with eye-bolts, with shackle attached, then move barge, allowing panel to slide along launching ways; when bottom wale gets to water elevation attach tie rod of sheet pile to panel with shackle; set and drive 3 by 12 sheeting in place. Third step: Move erecting barge to clear panel. Set and drive panel in place, connect upper tie rod. After panel is set, drive remainder of sheeting, as shown dotted, and fill cofferdam with puddle.

Following is an outline of the method of placing the cofferdam framing: The holes for the eye-bolts at the inner wall of the cofferdam were bored beforehand in every sixth sheet pile, the location of the holes having been determined from a study of the penetration of test piles driven in 1912. When, in driving the tie pile, any one of the holes passed below the guide wale, an eye-bolt was pushed through and secured by bolting to an 8 by 12-in. block, long enough to bear on four sheet piles. The tie rods, linked with the eye-bolts, were temporarily secured to the sheet piling already driven in such manner as to be readily accessible. The framing of the outer wall, consisting of the waling and strips of sheeting at 6-ft. intervals, was assembled on a platform built on the side of a 25 by 100-ft. barge. A top wale was suspended, at the proper height, by light chain-hoists supported by trolleys running on a rail that rested on brackets secured to the side of the house on the barge. The sheeting strip at the mid-point of the wale, and the ends of the adjacent top wales with their corresponding sheeting strips, were secured to the hanging wale by the shackle eye-bolts used at the outer wall of the coffer. The second and third wales of the panel under construction and the ends of the corresponding wales of the adjacent panels were then secured to the sheeting strips, the bottom wales resting on the platform. The barge was then shifted back, and the assembled panel slid down a sloping way at the end of the platform; the chain hoists being run forward and slacked off as the barge was shifted. When any eye-bolt reached the water surface, the corresponding tie rod was swung over from the inner wall of the coffer and linked with the eye-bolt shackle. When the panel was lowered to the river bed the chain-hoists were detached and run back into position for the next panel. The intermediate strips of sheeting were then placed and pressed into the river bed about 2 ft., by resting a No. 2 Warrington steam hammer on their tops, then spiked to all wales above the water surface. The greater part of the puddle fill was excavated from the lock pit with an orange-peel dredge and deposited in the cofferdam at one handling, the remainder being taken from the river bed some distance below the lock site and barged to the coffer.

The cofferdam was built June 19 to July 25, 1914, work on the structure not being continuous. The inner wall (407 ft. long) was driven in the equivalent of 24 8-hour shifts of one driver crew; the coffer skeleton (447 ft. long) was erected in ten shifts—the maximum length of framing built in any one shift being 85 ft. The sheeting was placed in eleven shifts of one driver crew. Fender piles were driven later along the outside of the cofferdam at 12-ft. intervals to a penetration of 12 ft.

Construction work was prosecuted inside the cofferdam from the latter part of July, 1914, until the end of the following October, in which period the lock foundation was prepared, the lock floor concreted and the walls built to about two-thirds full height—or to an elevation corresponding to an 11-ft. river stage. The progress made being sufficient to permit the completion of the lock in a cofferdam consisting of the river wall and the two guard dams, the outer wall of the box cofferdam was removed in November, 1915. The inner wall of triple-lap sheet piling was afterwards cut off at low-water mark.

The maximum head on the cofferdam, during the time it was unwatered, was 11 ft. The highest river stage for the period was 2 ft., a zero stage obtaining the greater part of the time. The percolation was moderate, as far as it could be definitely observed. There were a great many strong boils in the lock pit, but as the temperature of the water from these was 60° F. when the river water tested 78° F. they evidently proceeded, in large part, from an underground flow tapped by the foundation piles.

The only unsatisfactory feature that developed in this cofferdam was heavy settlement of the outer wall, as compared with that of the inner one, causing a rather marked leaning of the whole structure towards the outside. It may be noted, however, that this cofferdam was never subjected to any decisive test, the maximum head that actually obtained being considerably less than that which the structure was designed to withstand.

The dam at Little Callao Landing was built, in 1915, in two cofferdams essentially like the one used for the lock, and described above; except that the outstream end of the one built contiguous to the lock, and about 30 ft. of the upstream and downstream sides adjacent to the outer end, was constructed as a regular puddle wall coffer, the ship-lap piling used in the outer wall being driven to a 12-ft. penetration. These cofferdams were satisfactory, but again there was no severe test. A 9-ft. rise occurred in September, 1915, when work inside cofferdam No. 2 was practically completed and its removal was in progress. The freshet caused a scour of about 5 ft. around the outer end of the cofferdam—a scour that would be disastrous to the usual box cofferdam with the light penetration commonly obtained for the wall sheeting.

The special organization used in constructing the lock cofferdam and labor cost per day, were as follows:

PLACING FRAMEWORK.

1 foreman, at $3.00	$ 3.00
4 laborers, at $2.00 each	8.00
4 laborers, at $1.75 each	7.00
9 rations, at $0.50 each	4.50
Total	$22.50

PLACING SHEETING.

1 foreman, at $3.00	$ 3.00
1 engineman, at $2.50	2.50
1 stoker, at $1.75	1.75
3 laborers, at $2.00 each	6.00
3 laborers, at $1.75 each	5.25
9 rations, at $0.50 each	4.50
Total	$23.00

The cost of the lock cofferdam is given in Table I. This table includes all puddle-wall cofferdams of importance built by hired labor on the Ouachita River. The figures cover the field cost of material, supplies and services, no overhead was included. The costs of the completed structures are compared both on the basis of unit length and unit volume.

TABLE I—COMPARATIVE COST OF COFFERDAMS, OUACHITA AND BIG SUNFLOWER RIVERS.

Classification.	Quantity.	Unit.	Unit cost.	Total cost.
Lock No. 3, Ouachita River (1913-'14) Box coffer only.				
Lumber, wales, sheeting and cross-struts	93	M bd. ft.	$62.62	$5,823
Round piles, fender	843	Lin. ft.	.25	211
Tie rods with nuts and washers	25,369	Lb.	.06	1,522
Puddle fill[1]	7,200	Cu. yd.	.26	1,872
Completed cofferdam, all temporary	640 7,200	Lin. ft. Cu. yd.	14.73 1.31	$9,428
Lock No. 3—Box coffer and adjacent sheet-pile wall.				
Lumber (sheet piling below final cut-off not charged)	148	M bd. ft.	$59.44	$ 8,797
Round piles (guide piles below final cut-off not charged)	1,867	Lin. ft.	.25	467
Tie rods, etc	25,360	Lb.	.06	1,522
Puddle fill[1]	7,200	Cu. yd.	.26	1,872
Completed cofferdam, temporary part only	640 7,200	Lin. ft. Cu. yd.	19.78 1.76	$12,658
Big Sunflower Lock, 1914 Modified box cofferdam.				
Lumber (sheet piling below final cut-off not charged)	62	M bd. ft.	$49.40	$3,062
Round piles (guide piles below final cut-off not charged)	1,192	Lin. ft.	.27	321
Tie rods, etc	18,940	Lb.	.07	1,326
Puddle fill[1]	1,820	Cu. yd.	.25	455
Completed cofferdam, temporary part only	427 1,820	Lin. ft. Cu. yd.	12.10 2.84	$5,164
Dam No. 4, Ouachita River, 1911 Puddle-wall cofferdam No. 2. (Inclosing dam abutment and the adjacent retaining wall.)				
Lumber	108	M bd. ft.	$61.26	$6,616
Round piles	1,975	Lin. ft.	.35	691
Tie rods, nuts and washers	5,317	Lb.	.05	266
Puddle fill[2]	2,425	Cu. yd.	.66	1,600
Completed cofferdam, all temporary	290 2,425	Lin. ft. Cu. yd.	31.63 3.78	$9,173
Dam No. 6, Ouachita River, 1912. Puddle-wall cofferdams Nos. 2 and 3.				
Lumber (sheet piling below final cut-off, inner wall not charged)	260	M bd. ft.	$62.57	$16,268
Round piles (part below final cut-off, inner wall not charged)	6,700	Lin. ft.	.59	3,953
Tie rods, nuts and washers	14,450	Lb.	.07	1,012
Puddle fill	7,200	Cu. yd.	.28	2,016
Completed cofferdam, temporary part only	790 7,200	Lin. ft. Cu. yd.	29.43 3.23	$23,249
Lock No. 8, Ouachita River (1908-'11)—Puddle-wall cofferdams for lock (No. 1) and dam (Nos. 2 and 3).				
Lumber	535	M bd. ft.	$61.83	$34,681
Round piles	10,771	Lin. ft.	.28	2,944
Tie rods, nuts and washers	52,786	Lb.	.06	3,396
Puddle fill[3]	10,479	Cu. yd.	.47	5,137
Completed cofferdams, all temporary	1,530 10,479	Lin. ft. Cu. yd.	30.17 4.41	$46,158

[1] See footnote to Table II. [2] Barged to cofferdam. [3] Greater part barged to cofferdam.

TABLE II.—COST OF COFFERDAM AT LOCK NO. 3, OUACHITA RIVER, AND ESTIMATED COST OF OTHER TYPES DESIGNED TO MEET IDENTICAL CONDITIONS.

(a) ACTUAL COST.[1]

Classification of work.	Quantity.	Unit.	Unit cost.	Box cofferdam. Ohio River type.	Box cofferdam. Ouachita River type.
Framing wales, sheeting at panel and half-panel points and cross struts	44	M. bd. ft.	$84.61	$3,723	$3,723
Sheeting not included in framing	49	M. bd. ft.	42.85	2,100	2,100
Wales, guide	7	M. bd. ft.	30.00	.....	210
Sheet piles, 10-in.	48	M. bd. ft.	57.60	.....	2,764
Round piles, guide	1,024	Lin. ft.	0.25	....	256
Round piles, fender	843	Lin. ft.	0.25	211	211
Tie rods, nuts and washers	25,360	Lbs.	0.06	1,522	1,522
Puddle fill	7,200	Cu. yd.	0.26	1,872	1,872
Completed cofferdam Temporary part only	7,200	Cu. yd.	1.31 1.76	$9,128	...... $12,658

(b) ESTIMATED COST.

Classification of work.	Quantity.	Unit.	Unit cost.	Box C. D. Sunflower River type.	Puddle wall C. D.
Framing—wales, sheeting at panel and half-panel points and cross struts	23	M. bd. ft.	$84.61	$1,946	.....
Sheeting not included in framing	25	M. bd. ft.	42.85	1,071	.....
Wales, guide	7	M. bd. ft.	30.00	210	.....
Wales, for puddle-wall coffer	26	M. bd. ft.	30.00	.....	780
Sheet piles, 10-in.	84	M. bd. ft.	57.60	4,838	4,838
Sheet piles, 7-in.	128	M. bd. ft.	57.60	.....	7,373
Round piles, guide	1,504	Lin. ft.	0.25	376	.....
Round piles, fender	843	Lin. ft.	0.25	211	.....
Round piles, for puddle-wall coffer	3,984	Lin. ft.	0.25	....	996
Tie rods, etc., box coffer	25,360	Lbs.	0.06	1,522	.....
Tie rods, etc., puddle-wall coffer	13,040	Lbs.	0.06	.....	782
Puddle fill	7,200	Cu. yds.	0.26	1,872	1,872
Completed cofferdam Temporary part, only	7,200	Cu. yds.	1.67 2.31	$12,046	...... $16,641

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[1] Except that the cofferdam is here assumed to be completely filled (which was not actually done). The unit cost used for the complete fill is that found for the puddle fill actually placed.

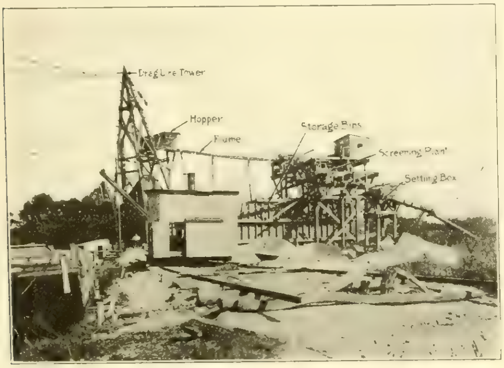
The structures compared were built under widely different conditions, and it is thought that a fairer comparison of cost can be obtained by assuming cofferdams of the several types, all designed for like heads and like foundations, applying the same unit cost to the same or similar classes of work. Such a comparison is made in Table II, the conditions for which the cofferdam at Lock No. 3 was designed being taken as a basis. The box cofferdam of Ohio River type (see table) will be that actually built at Lock No. 3, likewise the cofferdam designated as the Ouachita River type. The cofferdam of Sunflower River type will have its inner wall like the triple-lap sheet-pile wall at No. 3, but extended to the top of the coffer; its outer wall like the walls of the box coffer at No. 3; and its tie-rod system like that used at the Big Sunflower lock. The puddle-wall cofferdam will have an inner wall like that of the Sunflower type, waling excepted, and an outer wall of 7-in. triple-lap sheet piling driven to a 12-ft. penetration. Sheet piling will be estimated to run 12 piles to 13 lin. ft. of wall, this being the usual experience on the Ouachita with triple-lap piling.

Double tracking contracts amounting to about $4,120,000 were let recently by the Union Pacific Ry. Phelan-Shirley Company, Omaha, Nebr., secured the contract for the section from Archer, Wyo., to Pine Bluffs, 33.35 miles. The contract for the two sections from Point of Rocks, Wyo., to Wamsutter, 51.89 miles, and from Hermosa to Buford, 11.11 miles, was awarded to the Utah Construction Co., Salt Lake City, Utah. The latter work includes the construction of a tunnel about 1,800 ft. long to be constructed adjacent to the present single track tunnel at a cost of $500,000.

During the fiscal year ending June 30, 1916, 15,703,529 cu. yds. of excavation was done by dredges. Of this amount 3,984,897 cu. yds. was earth and 11,718,632 cu. yds. was rock. The unit cost was 27.786 cts. per cubic yard.

TRANSFORMING DRAG LINE SAND AND GRAVEL PLANT INTO A WASHERY.

A good example of what can be done in securing four or five sizes of cleaned products with a small expenditure for machinery is given by the installation of the West Jersey Sand & Gravel Corporation of Westville, N. J. The original plant was a drag line tower and a hopper which discharged directly into barges. To increase the capacity, a flume with screens and separator, were installed, the new plant washing and screening the sand. The hopper was left in its original position, a large drag line shovel was added, and the material flumed from the hopper to the screening plant by means of a jet of water. The accompanying illustrations show the improved plant.

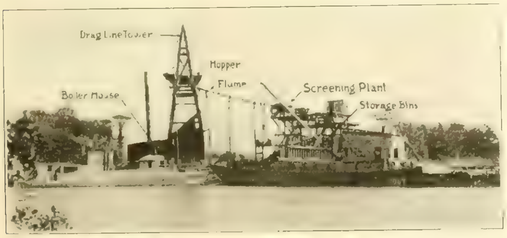


Plant of West Jersey Sand & Gravel Corporation, Westville, N. J.

H. B. Pratt, Philadelphia, was the engineer, the improvement being made by the Link Belt Co., Chicago.

The screening plant comprises three "Gilbert" type screens, which are so located that a duplicate set can be installed later. They are placed over three ground storage bins, which were made by building two partitions, thus getting three sizes of product on the ground. These screens are operated by Link-Belt drives from a small steam engine situated on top of the bins. The sand and water are separated by a counterweighted settling box, the Link-Belt sand separator, mounted on a small wooden tower.

The material in the ground storage piles is picked up and reclaimed by a mast and gaff outfit, which either builds out the storage piles for further capacity, or loads direct to the scows.

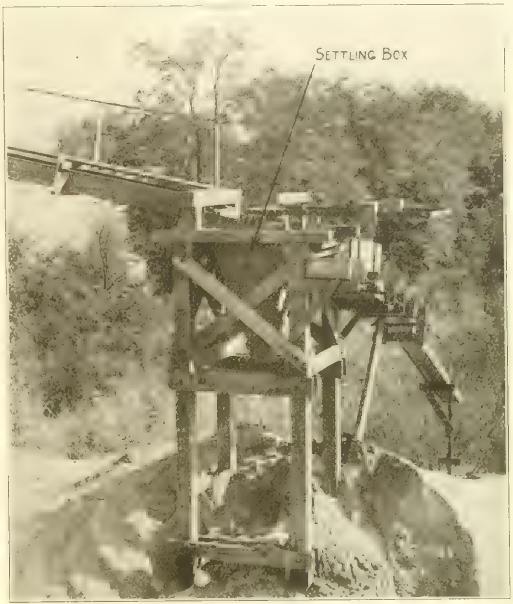


Loading Into Barges from Ground Storage Bins.

This plant is operated by four men—one in the drag line tower, one fireman, one man in charge of the screening plant and engine and one man on the mast and gaff outfit. The capacity is approximately 600 yd. in 10 hours, which can be doubled without much additional expense.

The entire plant is run by a 100-H.P. boiler. The water is elevated and delivered to the screens and flume by a two-cylinder steam pump, and, except for an occasional cleaning out of the fine mesh screen to remove pebbles that lodge in it, the equipment from the hopper to the sand piles requires no attention.

The use of ground storage bins in connection with a mast and gaff outfit, or locomotive crane, is a very economical way to equip a plant of this kind, as the amount of storage available is practically unlimited. The crane can be used to pull out the material from the ground bins, and build storage piles of any capacity required, which can be reclaimed readily by the same machine when delivering either to scows or cars.



Settling Box.

Cost of Gravel Production at Panama.—Sand and gravel for construction purposes on the Panama Canal was excavated during the last fiscal year by pipe line and ladder dredges from the gravel beds in the overflow section of the Chagres River, above Gamboa. The sand was passed through a ⅜-in. screen; No. 1 gravel over a 2-in. screen and No. 2 gravel through a 2-in. screen. During the fiscal year 1916 579,148 cu. yds. of gravel were produced, the detailed cost being as follows:

	Per cu. yd.
Unloading from barges	$0.0372
Switching	.0345
Hostling	.0006
Storing	.0102
Repairs to equipment	.0400
Dredging and towing	.2818
Miraflores storage pile	.0006
Plant arbitrary	.1000
Division expense	.0130
Total	$0.5179

The San Pedro, Los Angeles & Salt Lake R. R. has a construction and improvement program for 1917 calling for an expenditure of about $5,500,000. The work includes laying 200 miles of new 90-lb. rails, approximate cost, $1,500,000; additional ballast, $50,000; improving water supply at Las Vegas, Nev., $25,000; installing automatic block signals, $390,000; bridges, $120,000; miscellaneous betterments, $160,000; 750 self-dumping steel gondola cars, 6 cabooses and 6 giant locomotives of latest type, $1,800,000; and a new branch line 24 miles long from Pico to Santa Ana, Cal., costing about $1,400,000. Bridges include a steel span in Clover Valley wash, Nevada, and a large concrete arch over Sevier River, south of Lynndyl, Utah.

Robert Sherer & Co., Los Angeles, Cal., recently received a $1,400,000 contract for earthwork and masonry for a branch railroad from Pico to Santa Ana, Cal., for the Salt Lake Route.

COST OF CONSTRUCTING BECKWITH PASS TUNNEL OF WESTERN PACIFIC RY.

The Beckwith Pass Tunnel of the Western Pacific Ry. at the summit of the Sierra Nevada mountains was constructed between 1906 and 1909. It is a single track bore 6,000 ft. in length. The roof of the tunnel is 24.08 ft. above the top of the foot block; the top of the wall plate is 16.54 ft. above grade, and the width between plumb posts is 17 ft. Cost data on the construction of this tunnel are given by H. Devereux, consulting engineer, San Francisco, Cal., in the February Western Engineering, from which the matter in this article is taken.

The quantities per linear foot of tunnel were as follows:

EXCAVATION, CU. YD.

	Heading.	Bench.
Neat section	3.25	10.39
Enlarged section, side-lagged	4.905	12.351
Enlarged section, lagged	.....	12.04
Enlarged section, increase lagged	.....	1.961
Packing between lagging and 3-in. line	0.267	0.306

TIMBER, FT. B. M.

	Heading.	Bench.
Solid sets	327.4	408.0
2-ft. centers	285.0	210.4
3-ft. centers	234.6	141.6
4-ft. centers	209.4	107.2

For full lagging, add 124 ft. B.M. per linear foot of bench.

IRON, LB.

	1-bolt	2-bolt.	Large washers.
Solid sets	10.786	11.571	12.000
2-ft. centers	5.687	6.374	6.750
3-ft. centers	3.944	4.355	4.881
4-ft. centers	3.056	3.607	3.906

Large washers were used after Nov. 1, 1907.

The following scale of wages was in force. As a result of the business depression, the force and in many cases, the wage-rates were reduced on Nov. 25, 1907. Wages are per day unless otherwise noted. Men paid by the month received their board also.

	Before Nov. 25, 1907.	After Nov. 25, 1907
Foreman	$4.50	$4.50
Machine-men	4.00	3.50
Machine-helpers	3.50	3.00
Shovelers	3.00	2.50
Teamsters	3.00	2.50
Cornermen	3.50	2.75
Nippers	3.00	2.50
Carpenters	4.00	3.50
Carpenters' helpers	3.00	2.50
Pump-men	3.00	3.00
Steam-shovel engineer	150.00*	150.00*
Steam-shovel cranesmen	100.00*	100.00*
Dinkey skinners	75.00*	75.00*
Brakemen	50.00*	2.50
Pitmen	3.50	2.75
Dumpmen	2.50	2.25
Timbermen	3.00	2.50
Outside laborers	2.50	2.00
Two-horse teamsters	2.75	2.50
Blacksmiths	100.00*	3.50
Blacksmiths' helpers	2.75	2.50
Electrician	75.00*	75.00*
Compressor engineer (day)	90.00	90.00*
Compressor engineer (night)	75.00*	75.00*
Master mechanic	125.00*	110.00*
General foreman	150.00*	150.00*
Car repairer	75.00*	75.00*

*Per month.

The following force was employed during December, 1907, when both headings were closed:

OUTSIDE OF TUNNEL

	East end		West end	
	Day.	Night.	Day.	Night.
Compressor engineer	1	1	1	1
Compressor fireman	1	1	1	1
Dinkey skinner	1	1	1	1
Brakemen	1	1	1	1
Dumpmen	2	2	3	..
Blacksmiths	2	..	1	
Blacksmiths' helpers	2	..	1	..
Carpenters	1		1	.
Electrician	1		.	1
Car repairer			2	..
General foreman	1	.	1	.
Total	13	6	13	5

IN THE TUNNEL

	East end		West end	
	Day.	Night.	Day.	Night.
Foreman	1	1	1	1
Drillers	4	3	3	3
Chuckers	4	3	3	3
Nipper	1	1	1	1
Shovelers	8	8	16	16
Cornermen			4	4
Pitmen	4	4	.	..
Teamsters	2	2	1	1
Timbermen	6	.	6	..
Jumbo crew		.	1	1
Shovel crew	2	2		..
Total	32	24	36	30

When the headings were being driven an additional force of 21 men per shift was required inside the tunnel, or 84 men in all. On the outside, 7 additional men were required on each shift on the west end, and 3 additional men on each shift on the east end, or 40 in all. On the west end, a traveling platform called a "jumbo" was used to load the material, and on the east end, a model No. 20 Marion shovel operated by air.

The rock at the west end was a decomposed granite. At the east end the granite was hard, "blocky" and "seamy." The cost per cubic yard to the contractor was as follows:

	Heading.		Bench.	
	East.	West.	East.	West.
Drilling and blasting	$3.65	$2.93	$2.10	$1.20
Shoveling and loading	1.95	2.14	1.15	1.50
Powder	0.80	0.35	0.20	0.12
Outside men	0.63	0.55	0.35	0.30
Plant	0.49	0.33	0.32	0.19
Fuel oil	0.69	0.59	0.43	0.29
Superintendence	0.20	0.17	0.11	0.10
Total	$8.41	$7.06	$4.66	$3.70
Labor timbering	0.58	0.73	0.25	0.45

Average, $5.40 per cubic yard.
Powder cost, $0.15 per lb. and fuel oil, $1 per barrel.

PRODUCTION COST OF WASHED SAND AND GRAVEL.

Some interesting figures on the cost of producing sand and gravel were given by Mr. B. E. Neal, secretary-treasurer of the Indiana Sand and Gravel Producers' Association and vice president of the Neal Gravel Co., Indianapolis, Ind., in a paper presented Dec. 28 before the joint meeting of the Indiana and Illinois Sand and Gravel Producers' Associations. In submitting the figures Mr. Neal called attention to the fact that the gravel business was a spasmodic one, and that in a year there was only about 4 months of good business, 4 months of business taking about 50 per cent of the output and 4 months when they had no business at all, with heavy expenses for repairs, replacements and carrying the organization through the winter.

A summary of Mr. Neal's figures shows the following:

	Per ton. Cts.
Plant cost operating	12½
Plant cost stripping	2
Plant cost repairs and replacements	6
Office and selling expense	5
Taxes and insurance	½
Plant depreciation	3
Depletion of gravel deposit	1
Interest on investment, 5 per cent	1
Total	31

These figures Mr. Neal believes are about the average cost of producing commercial material under average conditions. By average conditions is meant a bank of gravel 30 to 40 ft. thick covered with about 3 ft. of stripping and running about 40 per cent above the ¼-in. and 60 per cent below. The above conditions are believed to be at least as good as are found in the average pit in Indiana.

The item operating cost includes the cost of loading and washing gravel, the cost of power and labor to transport the gravel from the bank to the plant and the cost of the monthly men while not actually engaged in repairs; also the cost of fuel or electric power, as the case may be. Mr. Neal stated that the experience of his company showed the cost of producing salable material, not considering the material wasted in a production, to be not far from 12½ ct. per ton.

The cost of stripping item varies more or less with local conditions. To move the stripping and get it clear away from the scenes of operation, Mr. Neal believes, would cost on an average 30 ct. per cubic yard of stripping moved. This in the case of the bank mentioned above would make the average stripping cost 2 ct. per ton of gravel. Regarding the item repairs and replacements Mr. Neal calls attention to the fact that producing gravel is heavy and hard work and is the hardest usage that machinery of all kinds can be put to. He believes the average repairs for plants, including repair labor, will average 6 ct. per ton on the year's output.

Plant depreciation is figured on the basis of 15 per cent per year. In giving this figure Mr. Neal states that plants of the cable excavator type must be moved every 3 or 4 years, and that plants of the elevator type with shovels and donkey engines have expensive machinery which does not last for many years. Mr. Neal doubts very much if this amount of depreciation would have covered the cost during the past 6 or 8 years, owing to the changes in gravel specifications which have necessitated rebuilding the plants. As a result of figuring over several plants, their costs and their capacities, Mr. Neal believes that it takes an average plant investment of at least 20 ct. a year to produce 1 ton of gravel. In other words, a plant which will produce 100,000 tons of commercial material could not be erected and made ready for business with a plant investment of less than $20,000. On the basis of 15 per cent depreciation this would mean a cost of 3 ct. per ton for gravel produced.

The item "depletion of gravel deposit" is figured on the basis of there being 65,000 tons of gravel per acre.

COST OF REPAIRS TO LOCOMOTIVE AND CARS.

Some interesting figures on the repair costs of locomotives and cars used in the transportation of copper ore are given in a bulletin issued recently by the U. S. Bureau of Mines. This bulletin, prepared as the result of investigations made presumably in 1914, describes the methods of prospecting and mining copper ore at Santa Rita, N. Mex., by the Chino Copper Co.

The loading of the ore and waste is done by steam shovels. To handle the trains of ore and waste 14 42½-ton and 7 50-ton, 4-wheeled Porter locomotives are used. These have cylinders 15 by 24 and 16 by 24 in. They are each manned by a locomotive engineer, at $4.25 per 10-hour shift, and a fireman, at $3 per 10-hour shift. The quantities of oil and fuel used by each locomotive per shift of 10 hours are about as follows:

Engine oil	1⅛ pints
Cylinder oil	1 pint
Cup grease	½ lb.
White cotton waste	½ lb.
Run-of-mine coal	3 tons

In general, there are always about two locomotives in the shop undergoing repairs. In addition, one locomotive is held just outside the shop with steam up ready for instant service. The total repair, upkeep, and all other expenses of the locomotives amount to 0.2 ct. per ton of material handled.

The ore cars in use are about as follows: 45 12-yd., side-dump, Oliver steel cars; 40 6-yd. steel cars not equipped with air brakes; 4 20-yd. steel cars fitted with air brakes, air-dumping appliances, etc. The four last-mentioned cars are leased from the Santa Fe Railroad, and have given such good satisfaction that the Chino Co. has ordered several of the new Clark 20-yd. extension dumping steel cars. These dump on either side, by air or by hand power, and are said to be satisfactory.

Ore that is fine enough not to need crushing is generally loaded directly into 50-ton steel railroad cars, the property of the Santa Fe Railroad Co., and is sent direct to the mill at Hurley without having to pass through the crushing plant just below the mine.

Table I shows the number of cars of each size loaded per month, during five typical months, and the cost of keeping them in repair. The repair cost per dry ton of ore handled and per cubic yard of waste is also given. The 50-ton cars are the property of the Santa Fe Railroad Co., but are kept in repair by the Chino company while used by them, and so are included in the repair account.

TABLE I.—COST OF CAR REPAIRS FOR FIVE TYPICAL MONTHS

Month, 1914.	Cost of repairs.			No. of cars loaded—			
	Labor	Supplies.	Cost per dry ton.	20-yard	12-yard.	6-yard.	50-ton
Cars Used in Mining Ore.							
January	$188.81	$196.19	$0.00196	.....	100	.	1,028
February	148.99	85.01	.00124	.....	4	. .	1,056
March	138.48	103.40	.00109	.. .	898	. . .	1,135
August	94.93	78.72	.00142	107	2,103	. ..	1,857
September	86.24	91.87	.00171	12	2,015		1,438
Cars Used in Stripping Waste.			Cost per cu. yd.				
January	$1,699.33	$1,765.73	$0.01122	.....	27,124	15,711	.
February	1,340.88	765.08	.00741	.....	29,573	13,043	
March	1,246.36	930.61	.00629	.....	34,525	16,105	.
August	854.35	708.48	.00838	1,017	10,169	10,778	12
September	776.17	826.86	.01008	1,548	9,511	9,065	14

MEASUREMENT OF POWER IN ROCK CRUSHING.

Rock crushing experiments conducted in the ore dressing laboratories of McGill University, indicate that in the reduction of any given rock there is a constant relationship between the power applied and the crushing effected, and that Rittinger's theory appears to conform agreeably with this relationship, while Stadler's theory, based on Kick's law, does not so conform. These investigations were made by John W. Bell, W. G. Mitchell, P. P. Baily and W. E. Cockfield, with the primary object of determining the relative value, for measuring the efficiency of crushing machines, of Kick's law (advocated by Stadler) and Rettinger's theory (advocated by Gates). An abstract of the result of the McGill experiments is given in the February Bulletin of the American Institute of Mining Engineers, from which the following is taken:

The aim of the laboratory experiments was twofold:

To measure as accurately as possible the maximum amount of crushing that can be effected by 1 hp. acting for 24 hours, by the two proposed methods for measuring the amount of crushing, namely: (a) by Rittinger's method; (b) by Stadler's method, based on Kick's law.

To show, if possible, that by one of these methods, the amount of crushing produced by 1 hp. in 24 hours is a constant amount throughout a wide range in the diameter of the piece crushed, and that by the other method, the amount of crushing is a variable quantity over the same range of diameter; or else show that neither of the proposed methods for measuring the amount of crushing indicates a fixed relation between power and crushing and consequently a new method for computing this amount will have to be found to permit the establishment of a law of crushing.

The following electrically driven crushing machines, installed and available in the McGill Ore-dressing Laboratory and which had been used in previous rock-crushing tests, on the whole seemed especially suited to the investigation: (1) Comet "A" crusher; (2) 7 by 9-in. Dodge crusher; (3) 10 by 16-in. rolls. In later tests a 3½-ft. Huntington mill was used.

In all the series of tests, except one, the rock crushed was a tinguaite—an intruded eruptive obtained from a local quarry. It is a hard and brittle rock, with a tendency to break rather more easily in one plane than in another at right angles to it. It, therefore, is inclined to break in slabs, although the fractured pieces are always irregular in shape.

In 1914, three series of tests were made to measure the work done per "apparent effective horsepower in 24 hours." In the first series the laboratory Comet "A" crusher was used; in the second series, the Dodge crusher; and in the third series, the rolls.

In certain respects the results of these tests were unsatisfactory, but the data obtained indicated strikingly the probability of a fatal error in Stadler's method and a degree of reliability in Rittinger's. The figures showed an enormous variation in the amount of crushing done by a measured horsepower through a wide range in diameter when calculated by Stadler's method, based on Kick's law, and a remarkable constancy when calculated by the law proposed by Rittinger in 1867. The comparative figures in Table I justify fully the indicated, but not necessarily proved, outcome of the whole investigation.

TABLE I. SUMMARY OF THE MOST EFFICIENT OF THE 1914 TESTS.

Test No.	Crusher.	Diameter of pieces crushed, in.	Work done per A.E. Hp.* in 24 hr. Measured in Stadler E. U.†	Work done per A.E. Hp.* in 24 hr. Measured in Rittinger S. U.‡
6	Gyratory	3.50	710	947
27	Dodge	[illegible]	520	1,030
34	Rolls	0.50	286	1,128
41	Rolls	0.25	138	1,000
47	Rolls	0.18	68	1,022
48	Rolls	0.11	89	1,187
49	Rolls	0.07	52	823

Total range ....50 diameters
Range in roll tests........................ 7 diameters

*Apparent effective horsepower. †E. U. = energy units. ‡S. U. = surface units.

In the fall of 1914, the fourth series was commenced to investigate in more detail the effect of "tonnage" and "work done per ton" before adopting a set procedure for the final series with rolls.

The decrease in efficiency which results by increasing the feed tonnage, or by increasing the crushing work per ton, for sizes 0.46 in. in diameter and upward was clearly indicated by the results obtained.

The sudden increase in efficiency, when the feed diameter is reduced to 0.30 in., is explained by the marked change in the sound and vibrations emanating from the machine. When crushing 0.46-in. feed at the 30-ton rate, the vibrations in the laboratory concrete floor were perceptible 20 ft. distant from the rolls. When crushing 0.30-in. feed, the floor vibrations practically disappeared, and there was a marked diminution in the smashing shocks, resembling a series of explosions, which were so pronounced during crushing of the larger feeds. In the next and succeeding smaller sizes the characteristic sound effect may be described as being in the nature of a steady grinding noise, indicating that a more uniform pressure replaces the fluctuating and violent forces transmitted to the journals during the crushing of the larger pieces. That there should be an enormous decrease in machine efficiency under the stated circumstances, is in the writer's opinion opposed to reason and common sense, and yet that is the one and only conclusion that can be reached by acceptance of Stadler's theory based on Kick's law, as will be apparent by examination of the data in Table II and Fig. 1.

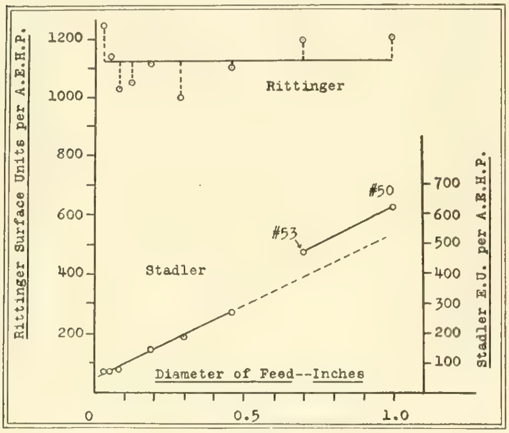


Fig. 1.

TABLE II—SUMMARY OF RESULTS OF 1914-1915 ROLLS TESTS.

Test No.	Remarks.	Diameter feed. In.	Tons crushed in 24 hr.	Work done per ton, Rittinger S. U.	Work done per A. E. hp. Stadler E. U.	Work done per A. E. hp. Rittinger S. U.
50	....	1.00	12.2	6.9	623	1,198
53	....	0.70	10.2	9.8	472	1,192
60	....	0.46	5.8	20.6	272	1,097
79-88	Average 9 tests*	0.30	28.7	21.3	190	1,002
89-93	Average 5 tests	0.19	31.3	30.9	150	1,115
94-97	Average 4 tests	0.12	33.8	22.6	109	1,054
98-101	Average 4 tests	0.08	34.5	31.8	82	1,028
102-105	Average 4 tests	0.05	31.6	21.5	77	1,137
106-109	Average 4 tests	0.03	29.8	28.0	77	1,250

Range 33 diameters. Average R. S. U., 1,120.
*Test 86 excluded.

The Stadler energy unit varies depending not only on the diameter of the feed, but on the work done per ton as well. In tests 50-53 the "work done per ton" is less than in the remaining tests (see Table II and Fig. 1) and the Stadler efficiency increases correspondingly.

It follows that there are an infinite number of values of this apparently misnamed "energy unit of crushing," consequently it is not a unit indicating a fixed relation between power and crushing when the material crushed is rock, however applicable it may or may not be in estimating the power required to crush an ideal and more or less imaginary substance. The unavoidable conclusion to be drawn from the experiments is that the Stadler energy unit is of no value in determining the relative efficiency of various types of rock-crushing machines. For a single machine, crushing feed of limited range in diameter with only a small variation in the work done per ton, Stadler's theory, based as it is on one of the manifestations of crushing, shows the character of the changes in efficiency produced by changes in adjustment, but the Rittinger system, even if it fails to conform with a law, is preferable by reason of its greater sensitiveness to small variations in the amounts of crushing.

The sudden increase in the work per apparent effective horsepower in the last four tests (see Table II), indicated the importance of investigating the relation of power and the crushing of rock particles of very small diameter. For this test a Huntington mill, with some modifications, was used.

TABLE III—SUMMARY OF AVERAGE RESULTS, HUNTINGTON MILL TESTS.

Test No.	Remarks.	Grade.	Diameter feed. In.	Work done per A. E. hp. Stadler E. U.	Work done per A. E. hp. Rittinger S. U.
114-115	....	+ 20	0.031	55.0	1,590
116-119	....	+ 30	0.020	47.5	1,860
120-122	....	+ 40	0.014	45.5	2,030
125-127	....	+ 60	0.009	34.2	1,970
128-129	Test 130 excluded	+ 80	0.007	28.1	1,910
131-132	....	+ 100	0.005	20.2	1,800

Range of diameter tested, 6.

The results in Table III show the characteristic drop in Stadler units per apparent effective horsepower, although the range of diameters tested is not large. However, many more experiments would be required to determine the effect of alterations in tonnage, percentage of water in pulp, speed of machine, etc.

Test 116 was made to obtain an indication of the effect of a reduced tonnage. The number of Rittinger units appears to increase, but several check tests would be required to form a definite conclusion.

Considered as a whole, the results are in closer agreement with Rittinger's theory than could be expected, when two obstacles which conspire to defeat the purpose of the investigation are taken into account. One, is the difficulty of measuring the power used only in crushing. The second has to do with the measurement of the surface in the —200 grade. Nobody has yet made a reliable measurement of this, and it is probable that it is a variable factor. For the —200 grade, Stadler's ordinal number 28 was adopted, for although it was realized that it was not necessarily an accurate estimate of the average volume of the particles it was supposed to represent, it would at least serve to make the comparison as fair to one as to the other theory. The corresponding Rittinger number is 780, which was adopted. It is probable that the average factor is appreciably greater than 780.

If in going from coarse to fine crushing there is a considerable decrease in surface in the —200 grades, the results tabulated in this paper would be appreciably affected, although the effect of such a variation would be more disastrous to Stadler's theory based on Kick's law than to Rittinger's, and the Stadler units per apparent effective horsepower might in consequence approach perilously near to zero.

In this investigation, the desirability of crushing a quartz gangue was recognized as being of more interest to those engaged in practical work; unfortunately, however, none was obtainabld locally, and tinguaite was employed for the experiments. It was feared that to some extent the habit of fracture of tinguaite might have prejudicially influenced the results obtained, hence upon the conclusion of the Huntington mill tinguaite tests, a series of grades of quartz sand was prepared and used to determine this point.

Convincing evidence was furnished by the results obtained that the relation between power and crushing indicated by the tinguaite tests remains unchanged when the rock crushed is quartz, excepting that the crushing force is less.

A 1,000,000 cu. yd. floating dipper dredge job is being advertised for bids by the Arkabutla Creek Drainage District of Sensatobia, Miss.

LOADING ROCK BY AUTO CRANE.

An interesting method of loading rock is employed by A. Courchesne of El Paso, Tex., at his limestone quarries near that city. The stone is broken out by means of two large Ingersoll tripod drills and three Ingersoll Jackhammer drills, all operated by compressed air. The pieces of rock are piled into skips and are elevated and dumped by means of a Byers auto crane into motor trucks and wagons for haulage to the crushing plant, $\frac{1}{4}$ mile distant.

Byers Auto Crane Loading Rock at Quarries Near El Paso, Tex.

In all 15 skips, each of $1\frac{1}{2}$ tons capacity, are used. In this way there always is a supply of rock ready for loading. The hauling is done by two $3\frac{1}{2}$-ton Velie trucks and three 3-ton back dump wagons. The hauling cost per ton by motor truck is 4 ct. and by dump wagon 7 ct. The loading cost with the Byers auto crane is 2 ct. per ton. The outfit has a capacity of 500 tons per day.

THE RELATION BETWEEN ENGINEERS AND CONTRACTORS.*

There is a vast difference between contracts to buy and sell a staple commodity and contracts for the construction of a building, a subway, reservoir or other public utility. In all large undertakings it is practically impossible to foretell precisely what may be wanted—what will be best to meet conditions that can be revealed only as construction progresses. What contractors object to is the attempt of the engineer to shift the burden of this uncertainty entirely upon the contractor's shoulder by contract clauses.

The question of estimated quantities has been litigated many times and in several instances the courts have delivered very forcible opinions concerning it. There was the case of Robbins vs. City of New London. The Water Commission of that town had advertised a contract to build a dam. The information to bidders contained the usual clause that the estimated quantities were approximate and that the bidders must satisfy themselves of the conditions. Shortly after starting the work, the contractor discovered that the original quantities were grossly under-estimated—not always an unpleasant discovery—but in this case, the difference in quantities was such as to require entirely different plant than was originally contemplated. Because of the delay incident to installing new plant, and the discussion which arose with a view to securing different unit prices for the work, the engineer, pursuant to the authority in the contract, ordered the contractor to discontinue work and suit was brought to recover on their bond given for the faithful performance of the contract. The Court dismissed the suit against the contractor and in the course of its opinion defined the real character in law of these statements of estimated quantities. The opinion stated that the representations in the advertisement and the notice as to quantities carried with it

> the assertion of being made upon some basis of superior knowledge. Their purpose was to supply information to persons who were expected to act upon it in a business dealing with those who made it, and who were entitled to accept and act upon it as expressing what it purported to express, to wit, information having a basis in such superior knowledge.

Elsewhere in the opinion the matter is explained in other words:

> It is apparent that the facts involved in the statements and representations in question were such as not to be equally available to both parties, were not at hand or within the observation of the contractors, and involved investigation of conditions, study and computations for which expert technical knowledge was required. They were made by a party in a position to have, and who assumed to have, not only a superior knowledge, but also a knowledge which had a foundation in expert examination and study, and they were made for the purpose of being acted upon, and promptly acted upon.

A more recent case is that of the firm of contractors, Leary & Morrison vs. City of Watervliet, which was decided in one of the New York Supreme Courts last October. This contract was for a sewer and contained the usual clause about the quantities. Forming a part of the contract were drawings showing profiles of the sewer on which was a line marked "approximate rock line." As the work proceeded, rock was discovered where none was shown on the plan of a maximum depth of 14 to 16 ft., and this in a part of the town where the work was the most difficult owing to the proximity of buildings. The contractors sued for the extra cost of this work, and in awarding them judgment, the Court expressed itself in this language:

> A contractor should be held in strict compliance with the terms of the contract in the doing of all work according to the terms of the contract as illumined and explained by the maps, drawings, plans and specifications. The contractor should take every reasonable precaution to advise himself as to what he is undertaking and as to what he is reasonably expected to do.
>
> The city on its part should take every reasonable precaution and opportunity of informing itself through its engineers and experts as to what are the true conditions under which the contractor will be called upon to perform, also on its part to do in the way of preparation all that it reasonably undertakes to do, to the end that the contractor will not be required to do what he could not reasonably be expected to do.
>
> In other words, it is quite as important that a municipality should be held to as strict an accountability on its part as is the contractor, and that the city should not receive the benefit of work done and materials furnished by a contractor through a technical construction of the terms of a contract all to the advantage of one party who had the greatest opportunity to know what was actually required and expected to be done.
>
> The city fairly should be bound, to a reasonable extent at least, by the drawings which it presents to the contractors for their information. The city has every possible advantage in knowledge as to the conditions which exist, and, while it calls upon the contractors to find out for themselves, it can hardly be said that that means that the contractors should actually excavate before they begin their contract in order to find out what they may thereafter be called upon to do.
>
> If the city says that rock disappears from the surface and is not included within the line of excavation at about this point or that point, it should be held that the city meant about what it said.

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*Abstract of a paper presented by C. A. Crane, secretary the General Contractors' Association, at the thirteenth annual convention of the American Concrete Institute, Chicago, Feb. 8.

These two are not by any means all of the cases ruling on the representations of the advertised quantities and information. The highest Court in the land, the Supreme Court of the United States, has had the question before it on several occasions, two of which are worthy of mention.

In Hollerbach & May vs. United States, decided in April, 1914, the contractor sued to recover increased cost of removing a dam because the material encountered was entirely different from that as represented in the specifications. Mr. Justice Day in reversing the Court of Claims remanded it to that Court with directions to enter judgment for the contractors for the damages incurred because of the difference in character of material, and said in part:

> A government contract should be interpreted as are contracts between individuals, with a view to ascertaining the intention of the parties, and to give it effect accordingly, if that can be done consistently with the terms of the instrument. In paragraph 33 the specifications spoke with certainty as to a part of the conditions to be encountered by the claimants. The specifications assured them of the character of the material, a matter concerning which the government might be presumed to speak with knowledge and authority. We think this positive statement of the specifications must be taken as true and binding upon the government, and that upon it rather than upon the claimants must fall the loss resulting from such mistaken representations.

And again in Christie vs. United States, decided April 12, 1915, a case which hinged on erroneous borings, a paragraph in the specifications provided:

> The material to be excavated, as far as known, is shown by borings, drawings of which may be seen at this office, but bidders must inform and satisfy themselves as to the nature of the material.

These borings showed gravel, sand and clay of various descriptions and showed no other materials. As a matter of fact, the material proved to consist largely of stumps below the surface of the earth, buried logs, cement, sand and gravel, all of which was much more difficult and expensive to excavate than the ordinary sand and gravel, as described by the borings.

Justice McKenna, in delivering the opinion of the Court, said:

> There was a deceptive representation of the material and it misled. There were representations made which were relied upon by claimants, and properly relied upon by them, as they were positive. Besides it was admitted at the argument that time did not permit borings to be made by claimants.

When time is the essence of a contract it is reasonable to assume that the estimated quantities will be sufficiently accurate to indicate that the engineers have devoted enough preliminary study to their design and estimate to know that the work can be done within the time prescribed. As a matter of fact, nearly all contracts provide that time is of their essence, but they usually provide that if subsequently some of the items are very largely increased, the time for completion will be extended commensurate with the increase. That is such a plain business proposition that one would hardly suppose any other course would be taken.

Winston & Co. had a contract to construct a reservoir in the City of Pittsfield, Mass. They were to do the work within a certain contract time, and liquidated damages for non-completion within that time were $75 per day for the overtime. A detailed estimate of the quantities involved in the work was issued to the intending bidders. One of the principal items in the work was earth excavation, known as stripping. The engineer's estimate called for 37,000 cu. yds. and the actual quantity excavated was 96,000 cu. yds. Other items of earth excavation were estimated at 12,200 cu. yds. and the actual amount was 24,700 cu. yds. Because of these increases the contract was not completed within the schedule time. In fact, because of the increase the work was prolonged through the winter months, when it was impossible to do little, if anything, but inspite of this very glaring error in the engineer's estimate the contractor was held to the original time and the penalty of $75 per day for 8 months, over $15,000, was deducted from his final payment. The suit to recover these overtime charges is still pending in the Massachusetts courts.

These cases all hinge on underestimated quantities. Severe losses may be incurred from overestimated quantities, and a moment's thought will convince you of this. In figuring a piece of work, the contractor must take into consideration a number of items, and very important items which do not appear in the engineer's plans or in his estimate of quantities. I refer to the overhead, and in one of the engineering journals some time ago there was a list of 16 items comprised in this overhead, and that was a very conservative list. It included: (1) Expense of making up the estimate and bid; (2) cost of surety bond; (3) cost of liability insurance, workmen's and public; (4) cost of plant and equipment; (5) moving plant; (6) maintenance of equipment, including cost of repairs and supplies; (7) tools lost, broken and stolen; (8) wasted material; (9) demurrage; (10) losses due to weather conditions and damages by the elements; (11) payroll and expense of outfit in rainy weather; (12) water charges; (13) damages to private property; (14) cost of inspection of materials; (15) lost and damaged cement bags; (16) being a good fellow. To this list might be added, depreciation of plant, fees for various local permits, interest on borrowed capital, and one very important item which a contractor nowadays would be very foolhardy to omit, annual retainer to counsel.

Now this overhead, plus the profit, must be added to the cost of labor and material, and when unit bids are asked on itemized work, it would seem almost an office boy's job to opportion this overhead to the various items enumerated in the engineer's estimate. That would work out beautifully if the engineer's estimate were correct, but if the amounts of these items fall below the estimated quantites, a certain proportion of the overhead expense is lost. This is not at all an unusual experience, and to protect themselves the contractors have evolved a system known as "unbalanced bidding," in which they endeavor to place the greatest proportion of this overhead and profit on those items which their investigations lead them to believe are tolerably accurate.

There is a simple solution for this matter of overhead, and that is to include in the bid a separate item to cover the overhead charges, say a lump sum for the entire job to be paid in proportion as the work progresses. If this scheme were adopted it would remove the incentive for unbalanced bids, and at the same time assure to the contractor the actual expense that he was put to even though bidding quantities were considerably over-estimated.

Another very prolific source of contention on contracts is "extra work." On big work it is often recognized that extra work may be legitimate and necessary and we find in many contracts provisions for paying for it. This is the way a Philadelphia contract handled it:

> Extra Work.—Whenever, in the opinion of the Director of the Department of Public Works, it shall become necessary to use materials or perform labor which is neither contemplated in the plans of the work nor implied in the specifications referring to said plans, the contractor hereby agrees to furnish such materials and perform such labor as extra work, and agrees to accept in full payment therefor a price which shall be fixed by the Director of the Department of Public Works.

That may be better than nothing, but it's a long way from perfect. It's not fair to the contractor as it binds him to accept any arbitrary amount, and it's not fair to the public official who might sometimes be suspected of treating one contractor better than another.

On the New York subway contracts, extra work—that is, work not susceptible of classification under the schedule of unit prices in the bid—is paid for at the net cost of the labor and material, and, quoting from the contract "in addition thereto 10 per cent of such net cost for the use of tools and plant, superintendence and all other expense incidental to the performance of such work and the furnishing of such material."

Extra work on that basis means an actual loss to the contractor. Note that 10 per cent is allowed not for profit, but for tools, plant, superintendence and all other incidental expenses. It's a very unusual job where general expense, including those overhead items just referred to, totals as small as 10 per cent of the contract. The insurance alone, under the Compensation Law, on subway work is 14 per cent of the payroll, and insurance is not allowed, except in a few of the very recent contracts, in computing the net cost of labor.

Probably big construction contracts always will be more or less of a gamble, but as contracting is becominb more and more an exact science due to the presence of so many of our best engineers in that field, it would seem that many of the gambling elements could and should be eliminated. Take for instance the construction by the Government of the compensating dams along waterways that are especially susceptible to floods. These Government contracts generally call for a temporary cofferdam to be used in the construction of the work. The contract provides for payment of one cofferdam. If it be washed away, it must be replaced at the contractor's expense and all other damages sustained by the floods must be borne by the contractor. Because of the inherent gamble in this class of work, there are not many contractors in the country anxious to bid, and such as do, make very careful studies of average weather conditions in the watersheds which would be liable to affect the locality where the work was to be done; but the weather sometimes shows utter disregard for averages, and the result is that on some of these Government dams contractors have lost big sums of money. They take a gambler's chance on average conditions. If the conditions subsequently are more favorable than the average, the contractor makes a handsome profit, and if they are worse, as in the case of some recent work on the Ohio River, where eleven heavy floods, some of them reaching a stage of more than 40 ft. above normal, occurred within a period when not more than one or two floods were generally to be expected, the contractor loses heavily. It is unfair to the Government to have to pay more for its work than its reasonable value, and it's certainly unfair to the contractor to have to lose hundreds of thousands of dollars through agencies beyond his control. These contracts should provide a method of payment for flood damage. If there were no floods the Government would not be paying the big contingent overhead, and if there were, the contractor would be reimbursed merely for his loss. Public works are being constructed for the benefit of the community at large. If any damage occurs because of these unforeseen acts of nature, the community which is to benefit by the work should assume payment of the damage.

Unfair clauses, ambiguity in specifications or quantities, lack of inducement, all combine to pile up the cost of work. The personal equation of the engineer, too, is taken into consideration by the contractor in preparing his bid.

We have spoken of liquidated damages to be charged against the contractor for not completing his work on time. Suppose the contractor can finish ahead of time, is it fair for the owner to delay him, and make him maintain his plant and force when he could be using them to advantage elsewhere, because the completed work is of no especial benefit to the owner ahead of time? Isn't he entitled to liquidated damages for the owner's delay?

Here's an instance of that to show what I mean. On one of the large aqueduct tunnels in New York the contract time was 48 months. By good management and improved methods the contractor had completed 95 per cent of the work in 26 months. The remaining 5 per cent of the work consisted of the installation of some metal work to be furnished by the city and the placing of some concrete after the metal was in place. Somebody blundered and the metal was not delivered for 18 months after the contractor was ready to receive it. In the meantime the contractor had to keep his plant in place, maintain watchmen, pumps and a force to look after the plant, besides keeping his bond in force, losing the interest on the retained percentage amounting to half a million dollars and sundry other items. Eventually he finished the job just within contract time.

The only satisfaction he could get was sympathy. Everybody was sorry, but his work wasn't supposed to be done so quickly. Is that contractor entitled to damages because of that delay?

A gain prevented is a loss sustained, and a contractor is certainly entitled to damages for loss of the use of his plant and money which might well have been earning more money on other work which he was prevented from bidding on because they were unavailable. And the public has already paid in that instance. Not in increased cost of the work, but in inconvenience, for the contract extended through the busiest part of the city and shaft-structures and the unavoidable street obstructions, all constituted an injury to business impossible to reckon in dollars and cents.

On subway contracts now building in New York, the contractors complain that their working plans have been delayed for months after they were ready for them, thus retarding their progress, and it has been asserted that the serious accidents which occurred in two sections undoubtedly would not have taken place had the steel been erected. On those particular sections the steel plans had been delivered to the contractor only shortly before the accidents—nearly two years after the contracts had been awarded.

Those accidents cost the contractors some money—and the public paid, too, but their loss was in a measure not reducible to money damage.

A subway contractor stated that because of a 10 months' delay in deciding on a station location and consequent delay in receiving plans, the work was carried over into the period when labor and materials commanded very much higher prices, and the station cost him about $140,000 more than if it had been done ten months previously, when he should have had the plans. And it is only one of many similar cases.

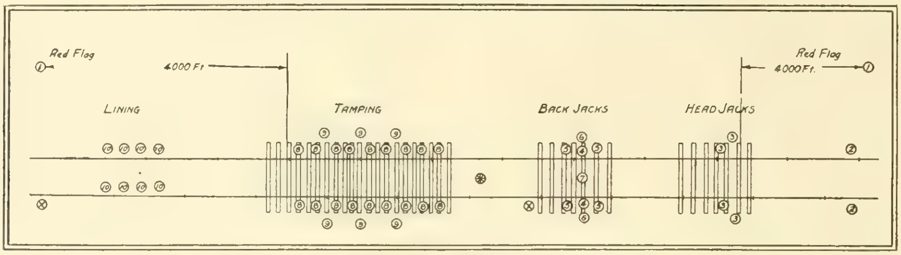
There is too often a woeful lack of co-operation between engineers, and contractors, and this is especially true of engineers on public work. The public's interest is nobody's interest, and work lags and drags in a manner totally absent from construction for railroads or other private utility corporations. One of the most intricate and stupendous pieces of work in connection with the Dual Subway system in New York was the third tracking of the elevated roads. This was a $15,000,000 job, and it was completed in less than two years. The work was designed by and done under the supervision of the engineers of the Interborough system and has been in operation for a year, while the men are still in some of the trenches under city supervision, which were started long before the third-tracking was begun.

Isn't this a big price for the public to pay? And isn't it an engineering duty—for it can't be called a problem—to reduce this high cost of public work? Some of it—a great deal of it—is caused by too drastic contracts—and a great deal more of it is due to the delay in proceeding with the work, all of which the contractor anticipates and charges for in his bid. Offer inducements to the contractor to complete his work ahead of time, and the saving, if only in the less inconvenience to the public, will be enormous.

Both tubes of the land tunnel of the rapid transit system under Willoughby St. and Montague St., Brooklyn, N. Y., between the Flatbush extension and Clinton St., are now "holed through" to the shaft at Clinton and Montague Sts. The south tube of the tunnel was "holed through" on Jan. 30 and the north tube last week. The tunnel forms a connection between the new under-river tunnel from Whitehall St., Manhattan, to Montague St., Brooklyn, and the Fourth Ave. subway in the Flatbush Ave. extension. The tunnel is entirely on land but was constructed by the shield method owing to the fact that it lies at great depth beneath the surface of the earth. Work was begun on both tubes of this tunnel on March 10, 1915, at Willoughby St. and Flatbush Ave. extension and work was prosecuted westward. The tunnel will cost approximately $2,000,000.

ORGANIZATION OF BALLAST GANGS FOR TRACK WORK.

The annual report for 1917 of the Ballast Committee of the American Railway Engineering Association contains the following information on organization of ballast gangs. Figure 1 shows the distribution of the gang as made by the New York Central R. R. for raising track on stone ballast. This diagram illustrates the arrangement of a force of 53 men, which is estimated to raise an average of 4,500 ft. of track per day.



New York Central R. R. Method of Raising Track on Stone Ballast.

No Men	Force.
2	No. 1—Flagmen.
2	No 2—Digging Holes for Jacks.
4	No. 3—Head Jacks.
2	No. 4 Back Jacks.
4	No 5—Tampers.
2	No. 6—Forkers and Sledge.
1	No 7—Levelman.
18	No 8—Tampers with Picks.
6	No 9 Forkers
8	No. 10—Lining Track
1	No. 11—Water Carrier.
1	Star—Foreman Supervising the Work.
1	Cross—Assistant Foremen Raising Track.
1	Cross—Assistant Foreman Lining Track.
	Number of Men, 50.
	Total Force, 53.
	Average, 4,500 ft per day.
	Average Back-Fill, 1,200 cu yds per day

The following organization of a ballast gang was drawn up by a sub-committee. This gang in the opinion of the committee, should complete 2,000 ft. of stone ballasting per day:

Inspector or general foreman.
Timekeeper.
3 Foremen.
3 Assistant Foremen.
110 Laborers.
Used as follows:
For skeletonizing and putting in ties:
1 Foreman.
1 Assistant foreman.
40 Laborers
For lifting and surfacing:
1 Foreman.
1 Assistant Foreman.
50 Laborers.
For resurfacing, lining and trimming:
1 Foreman.
1 Assistant foreman.
20 Laborers.
Inspector to be in charge of distributing stone.
Total men, 118.

The Delaware, Lackawanna & Western R. R. ballasted approximately 100 miles of double track on the Buffalo Division, raising the track about 12 in. and averages 6 in. raise for each "lift." Progress depended on local conditions, and to a large extent on train service.

The ballast gangs were organized as follows:

(1) 1 foreman, 1 timekeeper.
(2) Sub-foreman and 20 men.
This gang skeletonized the track.
(3) Sub-foreman and 10 men.
Where new rail had been laid this gang spaced the ties.
(4) Sub-foreman and 40 to 60 men.
This gang did the ballasting, raising both sides at once, using 4 to 6 jacks.
(5) Sub-foreman and 30 men.
This gang did the final surfacing and dressed up the ballast.

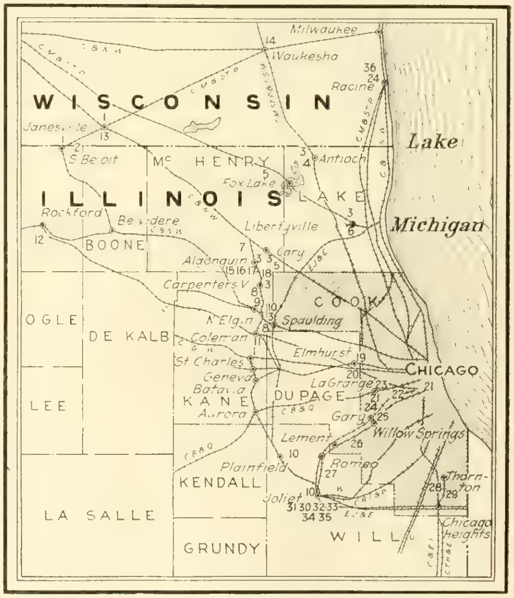
In November, 1908, the Richmond, Fredericksburg & Potomac Ry. organized a ballast gang which was made up as follows:

(1) One general foreman.
(2) One timekeeper and commissary clerk.
(3) One assistant foreman and 20 men.
This gang lifted the track, using the old ballast as far as possible, but not tamping any ties which were to come out.
(4) One assistant foreman and 20 men.
This gang regaged and renewed ties.
(5) Two assistant foremen and 40 men.
This gang applied the new ballast and surfaced the track, then dumped additional ballast for finishing and forming shoulder; this latter was plowed down as low as possible in center of track, the surplus being thrown by the plow outside the rail, leaving the track clear for traffic.
(6) One assistant foreman and 30 men.
This gang followed about 3 days in the rear of gang No. 3 and "caught up" any light settlement in surface, dressed up and finished the track, ready to turn over to the regular section gang.

The cost of this work was 26.15 ct. per cubic yard of gravel ballast applied.

SAND, STONE AND GRAVEL SUPPLIES ADJACENT TO COOK COUNTY, ILLINOIS.

An excellent system for furnishing prospective bidders with necessary information is being used by George A. Quinlan, Highway Superintendent of Cook County, Illinois, in connection with the placing of contracts for some $1,000,000 worth of highway construction. Two maps are furnished to the contractors taking out plans. One of these shows the location of the roads to be improved and location of railroad sidings with their car capacity. The other map shows the location of the sand, gravel and stone supplies adjacent to the county. This map is of interest, not only to the road builders, but to other contractors working in this locality. A reproduction of this map is shown herewith. The names corresponding to the numbers on the map follow:



Map Showing Location of Road Building Materials.

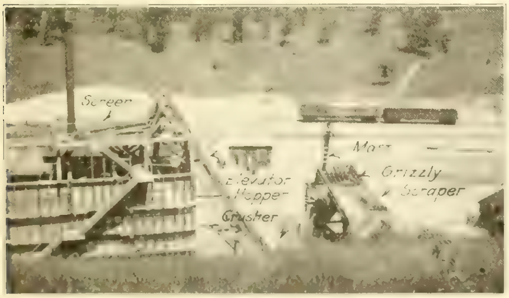
No.	Name, address, and location
1.	Great Western Sand and Gravel Co., National Life Bldg., Chicago, Ill.—Janesville, Wis.; South Beloit, Ill.; St. Charles, Ill.
2.	Atwood-Davis Sand Co., Merchants Loan and Trust Bldg., Chicago, Ill.—South of Beloit, Wis.
3.	American Sand and Gravel Co., 907 Chamber of Commerce Bldg., Chicago, Ill.—Antioch, Ill.; Libertyville, Ill.; Algonquin, Ill.; Cary, Ill.; Carpentersville, Ill.; Hammond, near Spaulding, Ill.
4.	James A. Buckley, 812 W. 55th St., Chicago, Ill. Antioch, Ill.
5.	Consumers Co., Consumers Bldg., Chicago, Ill.—Fox Lake, Ill.; Algonquin, Ill.
6.	Lake County Gravel Co., Insurance Exchange Bldg., Chicago, Ill.—Libertyville, Ill

7. Lake Shore Sand Co., 1120 Chamber of Commerce Bldg., Chicago, Ill.—Between Algonquin and Crystal Lake, Ill.
8. Richardson Sand Co., 921 Chamber of Commerce Bldg., Chicago, Ill.—Carpentersville, Ill.; Coleman, Ill.
9. A. Y. Reed Gravel Co., 12-14 Sherwin Bldg., Elgin, Ill.—North of Elgin, Ill.
10. Chicago Gravel Co., 1109 Fisher Bldg., Chicago, Ill.—Hammond, near Spaulding, Ill.; Plainfield, Ill.; Joliet, Ill.
11. Esson Sand and Gravel Co., 111 W. Washington St., Chicago, Ill.—Coleman, Ill.
12. Rockford Sand and Gravel Co., 609 Trust Bldg., Rockford, Ill.—Rockford, Ill.
13. Janesville Sand and Gravel Co., Janesville, Wis.—Janesville, Wis.
14. Waukesha Lime and Stone Co., Waukesha, Wis.—Waukesha, Wis.
15. Aetna Sand and Gravel Co., Algonquin, Ill.—Algonquin, Ill.
16. Pyatt Gravel and Sand Co., Algonquin, Ill.—Algonquin, Ill.
17. Reinert Brothers, Algonquin, Ill.—Algonquin, Ill.
18. Ready-Ryan Sand and Gravel Co., Algonquin, Ill.—Algonquin, Ill.
19. Elmhurst-Chicago Stone Co., Elmhurst, Ill.—Elmhurst, Ill.
20. A. C. O'Loughlin Co., 1019 Chamber of Commerce Bldg., Chicago, Ill.—Hillside, Ill.
21. Chicago Union Lime Works Co., 19th and Lincoln Sts., Chicago, Ill.—McCook, Ill.; Chicago, Ill.
22. Riverside Lime and Stone Co., 131 W. 63d St., Chicago, Ill.—Lyons, Ill.
23. Superior Stone Co., 326 W. Madison St., Chicago, Ill.—La Grange, Ill.
24. U. S. Crushed Stone Co., 108 S. La Salle St., Chicago, Ill.—Racine, Wis.; McCook, Ill.
25. Dolese & Shepherd, 108 S. La Salle St., Chicago, Ill.—Gary, Ill.
26. Illinois Stone Co., 29 S. La Salle St., Chicago, Ill.—Lemont, Ill.
27. Joliet Crushed Stone Co., room 3 Auditorium Bldg., Joliet, Ill.—Romeo, Ill.
28. Franklin Stone Co. (Pronger Bros.), Blue Island, Ill.—Franklin Station, between Harvey and Chicago Heights, Ill.
29. Brownell Improvement Co., 1220 Chamber of Commerce Bldg., Chicago, Ill.—Thornton, Ill.
30. Contracting and Material Co., 10 S. La Salle St., Chicago, Ill.—Joliet, Ill.
31. Ideal Crushed Stone Co., Joliet, Ill.—Joliet, Ill.
32. Joliet Artificial Stone Co., Joliet, Ill.—Joliet, Ill.
33. National Stone Co., Peoples Gas Bldg., Chicago, Ill.—Joliet Ill.
34. State Penitentiary, Joliet, Ill.—Joliet, Ill.
35. Western Stone Co., Joliet, Ill.—Joliet, Ill.
36. Universal Crushed Stone Co., 29 S. La Salle St., Chicago, Ill.—Racine, Wis.

A POWER SCRAPER GRAVEL PLANT INSTALLATION.

The County Commissioners of Racine County, Wisconsin, during the past two years, have been carrying out an extensive road building campaign. Increased progress along this line will be made durng the present season under a county and state plan. Gravel for the work and for other purposes is obtained from a plant owned and operated by the county.

The plant, whch is located on the Chicago, Milwaukee & St. Paul Ry. near Burlington, Wis., has a number of interesting features. The gravel is obtained from a bank on the side of a hill, in which considerable coarse material is encountered. The excavating is accomplished with a 1 cu. yd. Sauerman power scraper, operated by a 10x12 Thomas hoist with 80 H.P. boiler. The haul from pit to plant is about 300 ft.



Gravel Plant of Racine County, Wis.

The illustration shows the scraper as it is being pulled up the incline to the hopper. This hopper is provided with grizzly bars which keep out the stone over 10 in. size which is too large for the crusher. The material which passes through the grizzly bars drops down to a hopper which has an inclined screen at its bottom. The small gravel and sand pass through this inclined screen and on a chute down to the elevator boot. The material passing over this screen is spouted to the Telsmith crusher, where it is crushed, and the crushed material then passes by gravity to the elevator. The elevator carries the material to the screens located over the bins. The material is dry-screened, separated into three sizes and spouted to the different bins. When pit-run material is wanted, there is a by-pass at the top of the elevator which permits chuting the material direct to the cars on the siding.

The plant is under the charge of a county superintendent. The operating force consists of the following: One man loading cars, one man at screen and crusher, engineer and fireman.

The plant was operated from April until late fall during 1916 and furnished not only all the gravel for the county road work but also supplied a number of contractors.

BORINGS FOR CONTRACTORS' ESTIMATES IN SUBMARINE ROCK EXCAVATION.

Work is now under way in the First U. S. Engineer District, New York City, on the completion of a channel in the East River, New York, between North Brother and South Brother Island. The work required in making the channel includes the excavation to a depth of 26 ft. below mean low water of ledge rock and a layer of overlying compacted material varying in thickness up to about 7 ft. as a maximum.

Before commencing this work, it was realized that, owing to the strong tidal currents, and to the difficulty of penetrating this compacted material, the unit cost of securing by the usual method data for a reasonably accurate determination of the volumes of the materials to be removed, would be inordinately high; also that to require the dredging of the overlying material and the ledge rock in two operations, instead of one, would result in a comparatively high cost per unit of work accomplished. The measurement methods adopted are described by Mr. J. H. Rostock, U. S. Assistant Engineer, in the January-February Professional Memoirs, from which this note is taken.

It was finally decided to make the borings and secure the soundings from the drill boat employed on the work, as the work progressed, and not to require the removal of the overlying material before drilling and blasting the ledge rock. The method followed was, to some extent, governed by the conditions which controlled the movements of the drill boat. The currents being practically parallel with the axis of the channel and also very strong, the boat was necessarily placed in position fore and aft parallel to this axis, progress being made by moving the boat across the channel, or area to be excavated, in moves of 10 ft. each. The lines on which drilling was done were thus spaced 10 ft. apart. The holes to be drilled were also spaced 10 ft. apart on these lines.

The soundings and borings were taken at the points selected for drill holes, as nearly as practicable, by a leadsman under the direction of an inspector, both of whom were in the employ of the United States. In starting the work for any cross section the drilling machine, whose beam measurement was 35 ft., was placed in position with its drilling side outside of the area to be deepened and the other side on the limiting line of this area. Soundings and borings were then taken on both sides of hull until the drills reached this limiting line, when the latter were put in operation and the taking of soundings and borings was confined to the side of the hull opposite the drills. Since they were taken at each move of the drill boat, it follows that slope depths on the opposite side of the channel had been secured by the time the drills had completed work on the limiting line on that side. Also, since at least one measurement was taken at the ends of each line beyond the last hole to be drilled, the outside limits of the area covered by the soundings and borings were kept at a safe distance from the outside limits of the area likely to be disturbed by blasts.

Before commencing the actual work of drilling, tests were made to determine the practicability of utilizing measurements to ledge rock taken with the steel drill used by the contractor in his work. The results showed that depths secured in this way not only interfered with the contractor's operations, but were also greater than the true depths, the average of 25 measurements with the drill being 0.27 ft. greater than a corresponding number of measurements with a steel pointed pole.

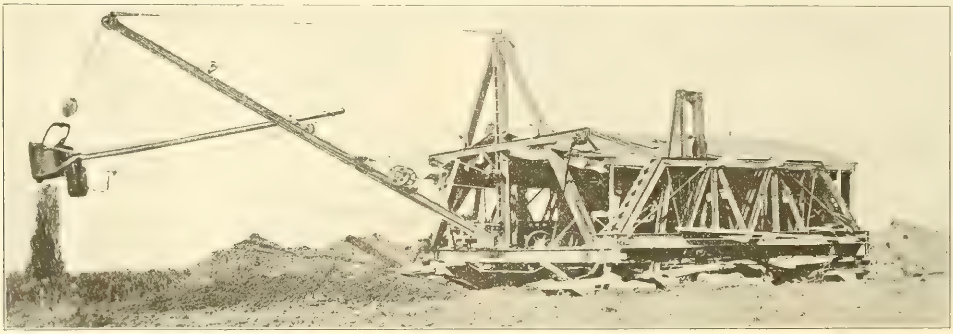
The work contracted for required the removal of about 24,000 cu. yd. of ledge rock and about 8,000 cu. yd. of overlying material from an area of approximately 26,500 sq. yd. in extent. All measurements for the determination of volumes have been taken, using the method described above, at a considerable saving in cost to the United States, and the measurements thus secured gave results at least as accurate as those secured by the method followed heretofore.

While it has been demonstrated that satisfactory results may be expected by the use of this method of measurement when the overlying material is of a character not likely to be disturbed by the blasting of the underlying rock, to such extent as to shift in position and form shoals in adjacent areas, it may seem improbable that like results may be obtained in localities where the overlying material is easily disturbed as, for example, soft mud or loose sand; but decision as to the method to be adopted should be made only after a careful investigation of the governing factors has been concluded. It is reasonable to expect favorable results when the covering layer consists of clay, stiff mud, gravel, or hardpan; on the other hand, when this covering layer consists of soft mud, loose sand, or other like material, the thickness of this layer, its position with respect to adjacent waters, the strength of currents, and other local conditions, as well as the requirements of the work, may govern, to a considerable extent, the choice of the method of measurement to be adopted.

NEW WALKING DREDGE.

A land dredge with several new features has recently been placed on the market by the Bay City Dredge Works of Bay City, Mich. This is a walking dredge using a series of feet in place of the steel trucks and sectional track for moving the dredge ahead on the work.

Four corner feet are attached permanently to the four corners of the dredge and two large movable feet are in the center, one on each side. The move-up cable passes over a set of sheaves and attaches to the upright or leg on each side above the middle foot. When the operator is ready to move up on the work he engages the clutches controlling the move-up drum, and as the cable tightens up it gives a lifting motion to the entire dredge, and transfers the weight of the dredge from the corner feet to the center feet. When the weight is removed from the corner feet the tension on the move-up cable causes the dredge to move forward over a set of rollers attached to the middle legs and resting under the longitudinal framework of the dredge.



Walking Dredge Specially Adapted to Working Over Rough, Marshy Ground.

The dredge moves forward 5 to 10 ft. at a shift, the center feet, which temporarily carry the weight of the machine, remaining stationary. When the operator has moved forward the required distance, the tension on the move-up cable is released and the dredge settles on the corner feet. The center feet are then pulled forward until the front of same are flush with the rear end of the front feet. The feet are then in position for the next step.

This move ahead motion is quite rapid and an experienced man can move forward at the rate of two steps in 60 seconds. It is possible to move across open country from one piece of work to another at the rate of 1 to 2 miles in 10 hours.

This walking dredge is specially adapted to working over rough, marshy, soft or slippery ground. No track, skids or extra planking are required and no track men are used. It is particularly useful in drainage districts where the yardage per station is small, where there are many laterals or where there are a series of short, detached ditches.

This walking dredge was in service during the digging season of 1916 in northwestern Minnesota, where it has been given a good tryout and thoroughly demonstrated. Other machines have since been fitted out in other sections of the country.

METHOD OF VENTILATING ROCK TUNNEL.

In driving rock tunnels through a rock fault in the Whipple mine of the White Oak Fuel Co. at Whipple, W. Va., circulation of fresh air at the face is obtained by means of 8-in. Flexoid tubing. Two tunnels were driven, each one being 6 ft. high, 10 ft. wide and 400 ft. long. They were driven through a very hard fine grained sandstone. The drilling was done by Jackhammer drills, and as all the holes are dry the work was very dusty. The shooting was done with 60 per cent gelatine dynamite.

The Flexoid tubing served to keep a circulation of fresh air, and to remove the rock dust while drilling and the smoke after shooting. The tubing was coupled to a Buffalo No. 3 volume blower direct connected to a 3 HP. Peerless electric motor. These blowers were set in the main entries adjacent to the tunnels. The Flexoid tubing lay on the floor, extending around a corner into the tunnel and along the floor of the tunnel. Near the face the end of the tubing was raised up and hung to the roof so that it pointed to the roof close to the face of the heading This arrangement seemed to work best for clearing the face of the rock dust while drilling.

Just before shooting, the fan was shut down and the tubing collapsed flat. Two men then put a drill through a center hole in a light wooden drum, making a reel and reeled up the Flexoid tubing without detaching it. After the shot they ran up to the face, reeling off the hose as they went. Instead of using couplers the ends of the sections were telescoped in the direction of the air current, and sewed with fine wire and covered with a short section of the tubing. W. H. Hyde, Pittsburgh, Pa., was the contractor for the tunnel work.

UNIT COST OF EXCAVATION FOR PANAMA CANAL.

The unit cost of dry excavation from the Panama Canal and auxiliaries for the fiscal year ending June 30, 1916, was 90.9 ct. per cubic yard. The unit cost of the dredge excavation was 25.9 ct. per cubic yard. Tables I and II. from the last annual report of the Governor of the Panama Canal, shows the quantities and unit costs of materials removed from the Panama Canal from 1904 to June 30 last:

TABLE I—QUANTITIES AND COSTS OF MATERIALS REMOVED IN THE DRY FROM THE PANAMA CANAL AND AUXILIARIES.*

Fiscal year.	Canal prism¹ Earth.	Canal prism¹ Rock.	Canal prism¹ Total.	Canal prism¹ Cost.	Canal prism¹ Unit cost.	Other than canal prism² Earth.	Other than canal prism² Rock.	Other than canal prism² Total.	Other than canal prism² Cost.	Other than canal prism² Unit cost.	Summary—Dry excavation Earth.	Summary—Dry excavation Rock	Summary—Dry excavation Total.	Summary—Dry excavation Cost.	Summary—Dry excavation Unit cost.
1904	24,024	36,083	60,107	$ 55,465.67	$0.9228	....	....	....	....	......	24,024	36,083	60,107	$ 55,465.67	$0.9228
1905	397,043	314,601	711,644	684,335.90	.9227	....	....	....	....	......	397,043	314,601	711,644	684,335.90	.9227
1906	764,327	742,235	1,506,562	1,390,172.27	.9227	....	....	....	....	......	764,327	742,235	1,506,562	1,390,172.27	.9227
1907	2,741,402	3,527,634	6,269,036	5,595,240.00	.8925	....	....	....	....	......	2,741,402	3,527,634	6,269,036	5,595,240.00	.8925
1908	7,683,938	9,838,965	17,522,903	15,005,288.22	.8563	....	....	....	....	......	7,683,938	9,838,965	17,522,903	15,005,288.22	.8563
1909	8,369,867	14,278,164	22,648,031	19,966,480.06	.8816	....	....	....	....	......	8,369,867	14,278,164	22,648,031	19,966,480.06	.8816
1910	5,539,423	14,361,240	19,900,663	14,139,750.07	.7105	....	580,098	580,098	$ 682,950.67	$1.1773	5,539,423	14,941,338	20,480,761	14,822,700.74	.7237
1911	5,448,371	14,818,203	20,266,574	12,565,476.27	.6200	692,395	2,079,747	2,772,142	1,902,534.18	.6863	6,140,766	16,897,950	23,038,716	14,468,010.45	.6280
1912	3,454,427	15,843,188	19,297,615	10,500,800.14	.5442	1,584,196	2,860,420	4,444,616	2,424,683.82	.5455	5,038,623	18,703,608	23,742,231	12,925,483.96	.5444
1913	3,788,635	12,512,130	16,300,765	9,635,242.48	.5911	1,753,732	2,175,236	3,928,968	2,231,894.61	.5681	5,542,367	14,687,366	20,229,733	11,867,137.09	.5866
1914	373,133	3,190,784	3,563,917	2,030,247.64	.5697	513,182	1,497,268	2,010,450	1,837,955.89	.9142	886,315	4,688,052	5,574,367	3,868,203.53	.6939
1915	....	....	....	(³)	......	61,439	491,397	552,836	456,558.88	.8258	61,439	491,397	552,836	456,558.88	.8258
1916	....	....	....	2,503.31	......	5,127	454,133	459,260	415,089.02	.9038	5,127	454,133	459,260	417,592.33	.9093
Total	38,584,590	89,493,227	128,077,817	$91,571,002.03	$0.71496	4,610,071	10,138,299	14,748,370	$9,951,667.07	$0.6747	43,194,661	99,631,526	142,826,187	$101,522,669.10	$0.7108

¹Includes all excavation for locks, dams, and canal prism.

²Includes excavation for Atlantic and Pacific terminals, Miraflores filter plant, permanent power house—Gatun, west breakwater, Toro Point, east breakwater Gatun borrow pits, Ancon quarry, and Porto Bello quarry, from Jan. 1, 1910, to date. ³A charge of $671,819.03 for Gaillard cut in 1915 was prorated over cut excavation 1904 to 1914.

*Table does not include excavation for the Panama railroad relocation or for dock and terminal work performed by the Panama railroad.

TABLE II—TOTAL QUANTITIES AND COSTS OF ALL MATERIAL REMOVED FROM THE PANAMA CANAL AND AUXILIARY WORKS BY DREDGING.†

Fiscal year.	Canal prism¹ Earth.	Canal prism¹ Rock.	Canal prism¹ Total.	Canal prism¹ Cost.	Canal prism¹ Unit cost.	Other than canal prism² Earth.	Other than canal prism² Rock.	Other than canal prism² Total.	Other than canal prism² Cost.	Other than canal prism² Unit cost.	Grand total of dredge excavating Earth.	Grand total of dredge excavating Rock.	Grand total of dredge excavating Total.	Grand total of dredge excavating Cost.	Grand total of dredge excavating Unit cost.
1905	111,376	......	111,376	$ 23,042.58	$0.2069			......	......	...	111,376	....	111,376	$ 23,042.58	$0.2069
1906	1,832,959	83,500	1,916,459	398,018.77	.2077			......	......	...	1,832,959	83,500	1,916,459	398,018.77	.2077
1907	2,306,611	43,602	2,350,213	487,832.08	.2076			......	......	...	2,306,611	43,602	2,350,213	487,832.08	.2076
1908	10,348,575	12,417	10,360,992	2,142,387.40	.2068	......	......	......	......	......	10,348,575	12,417	10,360,992	2,142,387.40	.2068
1909	14,211,569	417,621	14,629,190	3,037,231.38	.2076	2,513,183	27,889	2,541,072	$ 464,774.17	$0.1829	16,724,752	445,510	17,170,262	3,502,005.55	.2040
1910	14,443,462	369,421	14,812,883	2,820,561.98	.2388	1,462,263	179,152	1,641,415	1,641,059.98	.3536	15,905,725	548,573	16,454,298	4,461,621.96	.2712
1911	10,589,897	788,150	11,377,987	2,689,344.38	.2364	7,140,572	23,739	7,164,311	2,575,476.88	.3595	17,730,469	811,889	18,542,298	5,264,821.26	.2839
1912	7,777,637	977,477	8,755,114	1,946,251.51	.2223	5,016,781	83,648	5,100,429	2,283,070.34	.4476	12,794,418	1,061,125	13,855,543	4,229,321.85	.3052
1913	9,004,415	1,800,949	10,805,364	2,756,245.36	.2551	2,313,976	189,284	2,503,260	945,315.04	.3776	11,318,391	1,990,233	13,308,624	3,701,560.40	.2781
1914	7,165,472	3,863,169	11,028,641	3,381,927.96	.3066	2,990,506	283,006	3,273,512	1,188,306.40	.3630	10,155,978	4,146,175	14,302,153	4,570,234.36	.3197
1915	2,520,346	5,786,916	8,307,262	2,814,413.96	.3388	5,537,204	484,657	6,021,861	1,253,409.10	.2081	8,057,550	6,271,573	14,329,123	4,067,823.06	.2839
1916	3,040,884	11,001,263	14,042,147	3,789,477.10	.2699	1,978,701	806,963	2,785,664	573,966.28	.2060	5,019,585	11,808,226	16,827,811	4,363,443.38	.2593
Total	80,350,143	25,147,485	105,497,628	$26,286,734.46	$0.2492	31,953,186	2,078,338	34,031,524	$10,925,378.19	$0.3210	112,303,329	27,225,823	139,529,152	$37,212,112.65	$0.2667

†Also maintenance excavation.

¹Includes 1,121,788 cu. yd. rehandled in the canal prism.

²Includes excavation for locks, dams, terminals, harbors, sand and gravel service, and all other auxiliary excavation.

COST OF BLAST HOLE DRILLING WITH CHURN DRILLS.

Most of the blast hole drilling at the Santa Rita, N. Mex., mines of the Chino Copper Co. is done by churn drills. The ore bodies at Santa Rita are associated with quartz-monzonite and quartz-monzonite porphyry intrusions, the former constituting the largest mass. The total cost of drilling per ton of ore mined has been about 1 ct. and per cubic yard of material shipped it has been about 1.3 ct., according to a recently issued bulletin of the U. S. Bureau of Mines, from which these notes are taken.

The types of churn drill mostly used at Santa Rita are the No. 12 and the No. 14 Cyclone drills for big blast holes. They are fitted with Cook 12-HP. vertical gasoline motors, have traction gearing, and use 4-in. to 8-in. bits. Gas-engine oil, instead of gasoline, is used, and the consumption averages about 6½ gal. per 10-hour shift. The speed of drilling varies widely with variation in the hardness of the rock; however, the general average for blast holes not more than 65 ft. deep is said to be about 20 to 30 ft. per 10-hour shift. The crew of each machine consists of a driller and a helper; these two men can move the drill, even over rough ground, by turning on the traction gearing.

Each drill is fitted with equipment that enables the driller to sharpen his own bits. In general, the rock is soft enough so that one to two sharpenings per shift suffice. The blast holes are sampled if special information from particular localities is needed.

A few of the older steam-driven churn drills are now operated by air, piped from the compressor. In general, they are stated to be not as satisfactory as the oil-motor machines. There have been as many as 18 churn drills, both prospect and blast-hole, at work on the property at the same time.

The hydrothermally altered and considerably sheared character of the ore-containing rock facilitates the use of churn drills and is favorable for low drilling costs. Little trouble is encountered in putting down blast holes. Even in cutting across sloping sheared zones, a little care generally guards against such deviation from the vertical.

Records of blast hole churn drilling (day and night shifts) for two typical months, January and August, 1914, are given below:

	January (8 drills.)	August. (9 drills.)
Feet drilled	16,106	9,489
Total working hours	4,829	2,473
Average feet per hour	3.34	3.84
Time spent drilling, per cent	82.5	90
Time delayed, per cent	13.4	5.9
Time spent repairing, per cent	4.1	4.1
Average feet per hour of drilling	4.04	4.26

The cost of drilling blast holes with churn drills for the representative months of January and August, 1914, was as follows:

AUGUST, 1914.

Churn drill No.—	Cost of labor.	Cost of supplies.	Total.	Feet drilled.	Cost per foot.
1	[illegible]	[illegible]	$ 302.79	725	$0.4176
2	[illegible]	76.49	388.01	1,198	.3239
Total for steam drills using air	[illegible]	$149.85	$ 690.80	1,923	$0.3592
10	[illegible]	[illegible]	441.67	1,526	$0.2894
11	[illegible]	100.68	418.67	1,164	.3597
12	[illegible]	89.93	392.42	970	.4046
13	361.37	147.90	509.27	1,118	.4555
14	274.08	106.00	380.08	458	.8299
15	264.02	31.17	295.19	963	.3065
16	377.13	70.19	447.32	1,340	.3338
Total for gasoline drills	$2,277.50	$607.12	$2,884.62	7,539	$0.3826
Total for all churn drills	[illegible]	756.97	3,575.42	9,462	.3779

JANUARY, 1914.

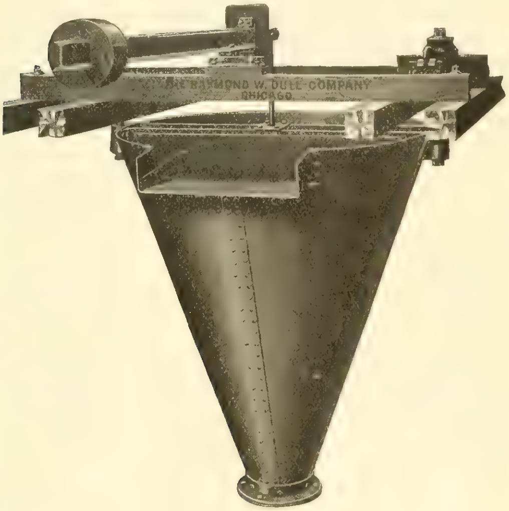
Churn drill No.—	Cost of labor.	Cost of supplies.	Total.	Feet drilled.	Cost per foot.
1	[illegible]	$ 183.40	$ 778.99	1,300	[illegible]
2	637.90	193.08	830.98	2,020	.411
Total for steam drills using air	$1,233.49	[illegible]	$1,609.97	3,320	$0.485
10	[illegible]	$ 195.21	$ 863.45	[illegible]	[illegible]
11	594.89	242.66	837.55	1,902	.440
12	622.02	176.92	[illegible]	2,456	[illegible]
13	[illegible]	190.99	814.23	1,941	.435
14	607.87	135.12	[illegible]	1,877	.396
15	618.97	[illegible]	863.85	2,103	.411
Total for gasoline drills	$3,765.23	$1,185.78	$4,951.01	[illegible]	$0.387
Toal for all churn drills	4,998.72	1,562.26	6,560.98	16,106	.407

CONICAL SAND SEPARATORS AT PLANT OF AKRON GRAVEL & SAND CO.

The washing and screening plant of the Akron Gravel & Sand Co., Akron, O., has an exceptionally well designed installation of sand separating tanks.

This plant has an equipment of 16 screens and 8 sand separators. The screens are arranged in sets of four and the sand and soil water from each set of screens passes to a pair of separators which clean and separate the sand into two sizes.

The separator used is the Dull conical separator, which is shown in the accompanying illustration. The feature of this separator is that it is practically automatic. At the bottom of the conical tank is an outward-opening valve, attached to a central rod extending down from the counter-weighted lever beam. The suspension and connections are such that the weight of the sand accumulation in the conical tank, overcoming the counterweight, causes a slight lowering of the tank and a farther lowering of the valve rod, opening the valve to permit escape of sand until reduction of weight causes closing of the valve. The separators at the Akron plant are 6 ft. across top of tank and 8 ft. from lever beam to bottom of tank.



Dull Conical Separator.

COST ACCOUNTING FOR THE CONTRACTOR AND ITS RELATION TO HIS ORGANIZATION.

In a paper presented at the recent convention of the American Concrete Institute Mr. Leslie H. Allen, of the Aberthaw Construction Co., Boston, Mass., points out how the data furnished by a cost keeping system can be made use of in the organization and supervision of the jobs and the carrying on of the general business of the contractor. Extracts from Mr. Allen's paper follow.

It is necessary to give a brief outline of the chief features of a contractor's cost system as follows:

First, the estimate: (a) An estimate for each job based on the costs of earlier jobs of similar nature. (b) This estimate analyzed to show first the quantities, unit costs and total costs of each item of labor, and then the quantities and estimated prices of each item of material and each sub-contract.

Second: A daily labor cost report showing the labor costs of each day's work.

Third: A weekly labor cost report showing in parallel columns the estimated and actual quantities, unit costs, and total costs of the work performed.

Fourth: A monthly statement of the cost of materials and sub-contracts purchased or ordered, showing in parallel columns estimated and actual costs.

Fifth: A final summary made at the close of the job showing the total cost of all labor and material.

Taking the chief features of a cost accounting system in order, we come first to the estimate. What use should be made of this? In many offices it is locked up in the safe the day the contract is signed and never sees the light of day again. The estimate is, or should be, the result of the estimator's study of cost data on preceding jobs, and is, therefore, the standard set for the cost of the job for which it was made. With it daily labor costs and material purchases should be compared. In making the estimate, the estimator has passed in mental review the whole sequence of job operations from start to finish and has described them in terms of quantity and cost. Read side by side with the plans and specifications it presents a complete view of the job from another angle and contains much valuable information that is most useful to, and should be made use of by, the contractor's force.

In order that it may be of the greatest possible use it should be in sufficient detail to show in separate items the various kinds and classes of work done by different gangs, and it is best to make an analysis of the estimate into two main divisions: 1. Labor; 2. Material, sub-contracts, and all items not classed as labor. The total of the first division, therefore, gives the estimated total payroll and shows how it is expected that this will be spent upon carpenters, masons, laborers, etc. The second division shows in detail the quantities of material, sub-contract work, etc., item by item.

Who should see and use this valuable information and work to these standards?

First: The general superintendent. It gives him a standard of performance by which he can measure up his job superintendents and foremen. It tells him more in a few minutes about the supply of materials and the sub-contracts than a day's studying of the plans would, and, in general, is a big help to him in supervising the employment, supply of material, progress, etc.

Second: The job superintendent needs to see the estimate more than any one. From it he can see what the firm expects him to accomplish in the way of costs and his criticisms of the estimate should prove helpful to the estimator. With it he can confer with the purchasing agent of the company and with the local dealers from whom he has to buy supplies and without a lot of computation on his part he can place the orders for much of his materials. From the sub-divisions of the analysis he can determine the sort of organization that should be placed upon the work, how many carpenter foremen, how many carpenters, the size of the labor gang, the number of mechanics, etc. He can be sure that by reading the estimate it will call to his mind all the work that has to be done and no important item is likely to be forgotten until towards the end of the job, too late to be worked in economically with the rest of the work.

The estimate shows him the quantities of materials he has to receive and he can plan for the efficient storage in convenient places for them and confer with the purchasing agent and the owners of the building in order to arrange how the materials should be bought, when and where they should be delivered.

Third: The purchasing agent. This man does not use the labor division of the estimate very much, but the material section gives him a list of all the items that he has to take care of. From it he prepares a more detailed schedule and by taking dates from the progress schedule he can prepare for his own use a list showing all materials required and the dates required in order that he may start in buying intelligently and see that everything is delivered on time. He has a valuable check on the bids received which is particularly useful when it happens to be impossible to get more than one or two bidders on an item.

Fourth: The scheduling men also should receive the material section of the estimate. They find from it what materials have to be scheduled, such as hard pine framing, reinforcement bars, sash, and other items on which an accurate buying schedule has to be prepared. They check their quantities by it. From the purchasing agent they receive notice of the date these schedules are required in order that he may buy them and have them delivered at the job in time.

Fifth: The foremen of brickmason, carpenter, concrete gangs, etc., should be told what the estimated costs of their work are, and shown from week to week how their work compares with the estimate.

The second important feature of a cost accounting system is a daily report of the labor costs. These are best prepared on the job, and on a well run system should be in the job superintendents' hands by 9 o'clock the next morning.

If each carpenter foreman is told what are the estimated costs on the operations he is to do and he is notified every day as to whether he is coming inside or overrunning his costs, it is sure to have its effect. We frequently plot the principal items on a chart graphically, which not only the carpenter foremen but the carpenters can see as they check in and out. We even draw similar charts for the concrete and steel work on occasion, and find that the lowest laborer takes a cheerful and even enthusiastic interest in the vagaries of the wandering line that shows the cost of the work he is doing, and where the work is large enough to allow of gangs competing on similar work the graphic chart is even more valuable.

We believe that it is best to keep the cost accounts on the job instead of in the head office. Costs to be of any use should be fresh and not stale. If the superintendent knows at 9 o'clock the very next day that concrete cost 20 ct. a yard more to put in than on the preceding day he can talk it over with his foreman while the matter is fresh and investigate and remedy the fault; but if the news does not come to him for a week or ten days after the work in question is done, it is too late to do anything. The daily reports come too often and in too much detail to be useful to the general superintendent. He would only be confused if he attempted to digest them.

It must not be supposed, however, that a system of daily cost reports will relieve the superintendent of any of his responsibilities. He is usually able to detect inefficient or expensive work by his own experience and observation without waiting for the costs to tell him. The daily costs do, however, point out an occasional high spot that he has missed. They are an unfailing barometer of the job. They strengthen his position with his men by backing up his judgment and are especially a very great help to younger superintendents.

The third essential of a cost system that has been mentioned is a weekly labor report. This should show in parallel columns the estimated and actual quantities, unit costs, total costs, and saving or overrun. The amount of detail will vary in different concerns, but in any case it should be in sufficient detail to give an intelligent account of the job operations. This statement should be furnished to the heads of the main office of the company as well as to the job superintendents, but accompanying it a simple summary should go to the heads of the company, the main facts condensed into a very few items so that they can tell at a glance, without a lot of study, how each job stands. This statement gives a sort of review of the job's operations to date. It should go to the general superintendent and the estimator in the head office. The latter particularly needs to know the fluctuations in costs in order that he may check up his judgment with actual facts and learn the costs of any new sort of work.

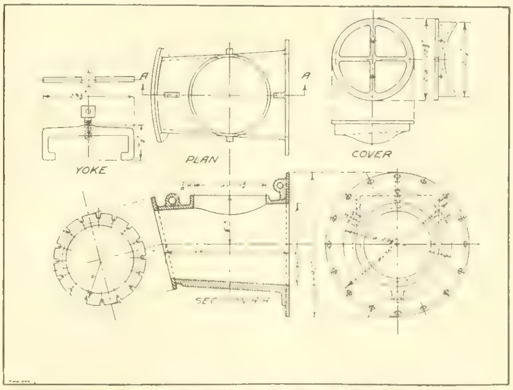
The fourth essential feature of a cost system which I have mentioned is a monthly report showing in tabular form the estimated and actual costs and quantities of the materials, and amounts of sub-contracts and other expenses incurred. It is not necessary to have a weekly statement of this nature, because differences between estimated and actual costs are not due to the good or bad supervision that the job is having, but are due to errors of judgment in estimating, unexpected rises or falls in the market, lack of information as to local costs, etc. It is, however, necessary that at least once a month track should be kept of the amounts gained or lost on the estimate. By adding together the savings or overruns on the labor and materials the contractor can tell every month just how far behind or ahead of estimate his job is, and can make an intelligent forecast as to how much can be saved or will be lost on the remainder of the job. Such information is rarely to be found in a contractor's office, but is of great value to him, and in itself is worth almost all the time and expense that should be put in on a cost accounting system. This statement should, of course, go to the job superintendent and to the general superintendent who are using the materials, and to the purchasing agent who spends the money, and to the estimator who finds it a most valuable check on his work, keeping him in touch better than anything else could with current prices. It is not enough for him to know six months after he has made an estimate that he has been wrong on some item. He should be kept constantly in touch in this way with the actual cost of the work that he is estimating.

The fifth essential feature is a final summary of the job costs made up in the same form as the original estimate, which should be filed for future use. A copy should be given to the job superintendent as a record of what he has accomplished, and to the general superintendent as a permanent reference for him, in order that he may have something to go upon in his criticism of future jobs. The estimator should have a copy as it is his chief authority for prices he places upon new estimates.

ROCK REMOVAL MANHOLE ON SUCTION PIPE OF HYDRAULIC DREDGE.

The manhole illustrated has been installed on the U. S. Government Dredge Clinton for the purpose of collecting stones and other large objects before they reach the pump and plug it or otherwise damage the runner. It is claimed that this arrangement gives better results than the stone boxes often placed in the suction line of hydraulic dredges. The device is described in the January-February Professional Memoirs, from which this note is taken.

The manhole is placed in a somewhat enlarged section of the suction line immediately ahead of the pump, and is made sufficiently large for the removal of any stone which could traverse the suction line to this point, and with a cover strong enough to preclude any possibility of its breaking, with the probable consequence of sinking the dredge. Usually the manhole cover is held in place by some form of yoke clamp; this arrangement, while giving the necessary strength, admitting of opening and closing the manhole with the least possible delay.



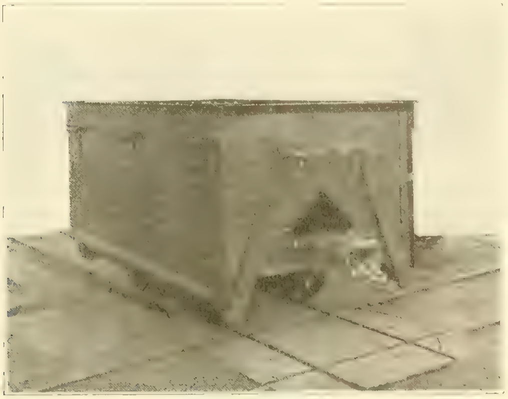
Rock Manhole Installed on U. S. Dredge De Witt Clinton.

The section of pipe containing this manhole is usually tapered, the diameter of pipe increasing toward the pump. This taper serves a two-fold purpose; first, that of increasing the annular space between the runner hub and nut and the pipe walls, thereby allowing small stones to enter the pump which would otherwise be stopped but which can properly be handled by the pump, and second, making easier the entrance of a man into the pump for the purpose of clearing or inspecting it.

IMPROVED GABLE BOTTOM IRON ORE CAR.

Gable bottom iron cars of the type illustrated are being used extensively for locomotive haulage in the Michigan and Minnesota ore ranges on account of their rugged construction and ease of operation. Some 30 odd of these cars have lately been shipped to the Pickands-Mather Co.'s properties in Minnesota by the Orenstein-Arthur Koppel Co. of Koppel, Pa.

The side door locking gear shown in the illustration is of special interest, as it will be noted that each door is held closed by a longitudinal shaft running along the bottom edge of the car underneath the door, the shaft being provided with manganese cast steel hooks which engage the bottom of the door. This shaft has a hand lever at one end and the lever is kept in position by means of a spring catch. Manganese steel wheels with caged roller bearings are used. The capacity of the car shown is 55 cu. ft. and the gauge 24 in.



Gable Bottom Iron Ore Car.

A CRUSHER OF 25,000-TON CAPACITY PER 20 HOURS.

What is claimed to be the largest crusher in the world was installed recently at the plant of the Michigan Limestone & Chemical Co. This company is operating a property in Northern Michigan on the shores of Lake Huron at Calcite, which is within a few miles of Rogers City. It comprises approximately 12,000 acres of limestone land. The quarry face at the present time is about 1½ miles in length and has an average face height of about 50 ft. A large number of churn drills are used for drilling the full height of the face which is shot off in successive layers with dynamite.

Six 110-ton steam shovels with 3½-yd. capacity dippers are used in shoveling the blasted material into trains of 8 to 10 cars of 10-yd. capacity each. These are hauled by steam locomotives on standard gage tracks. The trains are controlled by a tower man with an electric signal system so that the engine man of each train is shown which shovel he is to serve on each trip, and the delivery of the stone-laden trains is therefore systematically controlled for feeding the primary crusher.

As the tracks approach the crusher house they are arranged so that the stone can be delivered either side of the crusher. Up to the present time, all of the stone has been delivered to a No. 42 Kennedy gyratory crusher, which has been in service about five years, and has produced an average of about 16,000 tons of crushed limestone per 20-hour day. The recrushing operation to produce the finer sizes of stone required is accomplished with No. 7½ Kennedy gyratory crushers.

Recently this company has installed an additional primary crusher in order to secure a larger tonnage capacity, and also to receive larger stones so that the cost of quarry blasting would be minimized, and there will be less opportunity for any delay from pieces not entering the crusher on account of the receiving opening being of insufficient size. This new installation is a No. 60 gyratory crusher, made by the Kennedy-Van Saun Mfg. & Eng. Corp., New York City. It has a capacity of approximately 25,000 tons per 20-hour day, crushing limestone from a maximum size, which will enter its receiving openings, having a combined area of 60½ in. by about 35 ft. down to about 8 in. and finer.

The crushing space between the head and concaves holds 30 tons of stone and this, together with the hopper which flares out above the head and concaves with an outside diameter of about 22 ft., affords receiving capacity of over 65 tons of stone.

The main shaft is about 3 ft. diameter at its largest portion and about 28 ft. long. The total height of the machine is 34 ft. It is driven with 1¼-in. Manila ropes by a 66-in. cast steel sheave, having 18 machined rope grooves. It is operated by the English system, so, if as many as half of the ropes should fail from wear, the crusher can still serve, continuity of operation being of the greatest importance. The source of power is a 300-H.P. motor, which has been found ample for the requirements.

The broken stone from this crusher is spouted to a belt conveyor which carries it on an upward incline to revolving screens, the rejections from which are fed to smaller crushers producing the finer sizes of stone required. It is then either conveyed to ground storage or to bins from which it is loaded by shuttle conveyors on to specially built steamboats for transport on the lakes to customers, principally large steel producers who utilize this limestone for furnace flux.

PERSONALS.

C. M. Thompson has been appointed Division Engineer of the Union Pacific Ry., with headquarters at Denver, Colo.

T. M. Howerton has recently been appointed as Bridge and Road Engineer for Buncombe County, North Carolina, of which Asheville is county seat.

Hugh B. Holmes, heretofore resident engineer of the Kansas City, Mexico & Orient Ry., with headquarters at Kansas City, Mo., has been appointed chief engineer.

C. M. Ratliff, heretofore assistant engineer of maintenance of the Southern Ry., has been appointed office engineer of the system, with headquarters at Washington, D. C.

L. W. Duffer, chief engineer of the Meridian & Memphis Ry., has been appointed special engineer of the Gulf, Mobile & Northern Ry., with headquarters at Mobile, Ala.

Eric T. King, Assoc. M. Am. Soc. C. E., has been appointed Assistant Secretary of The General Contractors' Association, New York. Mr. King was for ten years an assistant engineer on the Catskill Water System for New York City, and latterly has been assistant to Lederle & Provost, Consulting Sanitary Engineers. He was graduated from Union College in 1905.

At the annual meeting of the American Institute of Consulting Engineers on Jan. 15th, the following were elected members of the council to fill the places of retiring members: A. M. Hunt, Lewis B. Stillwell, Wm. J. Wilgus, Gardner S. Williams. At the council meeting on Feb. 6th the following officers were elected for the year 1917: George Gibbs, president; Lewis B. Stillwell, vice-president; F. A. Molitor, secretary and treasurer.

Walter Kidde, Engineer-Constructor, of 140 Cedar St., New York, has incorporated his organization under the title of Walter Kidde & Co., Inc. Mr. Kidde's chief associates, who have been his partners on the "Carnegie Plan," now become directors and stockholders of the new corporation, the officers of which are: Walter Kidde, president; B. G. Worth, vice-president; I. R. Lewis, secretary and treasurer. These are all members of the board of directors, which also includes Henry Lang, who is vice-president of the Ingersoll-Rand Company, and E. S. Boyer, who is associated with the American Hard Rubber Company. Mr. Kidde's other principal associates, who comprise the "engineering board" of the new corporation, are: A. B Miller, Walter S. Wainwright, M. I Buttfield, and E. Schwarz. The chief draftsman is Thorlief Fliflet.

Dr. W. F. M. Goss, for many years associated with the Schools of Engineering, Purdue University, and since 1907, Dean of the College of Engineering of the University of Illinois, has resigned that office, effective March 1, 1917, to assume the presidency of the Railway Car Manufacturers' Association, an office to which he was elected on Feb. 1, subject to his release by the University authorities The Railway Car Manufacturers' Association is of recent origin. It is made up of representatives of 15 different organizations engaged in the manufacture of railway cars, freight and passenger. It will seek to establish cooperative relations with the purchasers of cars, and to aid especially in the matter of standardizing the design and specifications of cars. It will study problems of the industry as presented in the work of individual plants, such as cost accounting, welfare work, etc. The purpose of the Association, broadly stated, is to aid in increasing the efficiency of one of the country's great industries. It will work along broad lines on the theory that if the efficiency of the industry can be improved, benefits will accrue to the purchasers of cars and ultimately to all who use them.

INDUSTRIAL NOTES.

The Blaw Steel Construction Co., Pittsburgh, Pa., has opened an office in the Rialto Bldg., San Francisco, Cal. Edward M. Ornitz is in charge.

The Walter A. Zelnicker Supply Co., St. Louis, Mo., has purchased the Idaho Southern R. R., which runs from Gooding to Jerome, Idaho and the Milner & North Side R. R., a short line extending from Milner to Oakley, Idaho, comprising a total of approximately 50 miles. These railroads were built only a few years ago by Pittsburgh capital. It is understood the Walter A. Zelnicker Supply Co. will dismantle the roads and sell the rails and other equipment, which are practically new.

Buildings and Structures Issue
of

Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

First Wednesday Each Month............Roads and Streets......$1 Yearly
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Fifth Wednesday.......Planning and Management Quarterly...25 cts. Yearly
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Contract News Appears in All Issues

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WHEN IS IT PROFITABLE TO RETIRE AN OLD PLANT UNIT?

Business success often depends largely on the judgment used in scrapping a comparatively new plant to make way for a newer one. British manufacturers have been proverbially slow in retiring old machinery, whereas Americans have more often gone to the other extreme. Is there not some definite criterion by which to decide when it is no longer economic to use old machinery? Undoubtedly, but it is not to be found in any book on economics. In fact, a correct formula for solving this important economic problem exists in no book known to the editor.

The problem has been put to a score of engineers, to several skilled accountants, and to a few business men, not one of whom gave a completely correct solution. It was submitted also to a well known business correspondence school, which likewise failed to give a correct answer. That school in turn passed the problem on to an expert accountant and to a well advertised "efficiency engineer," both of whom gave erroneous replies. It may be assumed, therefore, that the problem is of a sort whose seeming simplicity is itself a cause of hasty reasoning where deliberate and painstaking study is actually required.

This is a case where it will not suffice to give an answer in general terms without explaining in detail the precise quantitative meaning of every economic term. Thus, one general rule that was submitted to the editor was this:

Retire any old plant when the annual profit will be increased by substituting a more economic plant.

This is correct as far as it goes, but it is completely correct only when the term "profit" is fully defined. Since profit depends on cost, a definition of cost must be given, even to every element that enters into cost. As will be shown later, the cost elements are numerous and several of them are not understood even approximately by most men.

Professor Taussig, of Harvard, gives a general rule in his "Economics," Vol. II, p. 85, as follows:

> It will be profitable to tear down an old or ill-adapted building and replace it with a new building only when the new one promises to yield not only enough to pay a satisfactory return on its own cost, but in addition enough to compensate for the loss of net revenue which the old one still yielded.

Here the ambiguous terms are "a satisfactory return" and "net revenue," both of which require no small amount of explanation. Prof. Taussig's rule borders dangerously close to an error that is most commonly made in attempts to solve this problem. It is quite generally believed that a new plant can not economically replace an old plant unless the net earnings that the new plant yields are sufficient to pay interest charges on the original cost of the old plant as well as on the first cost of the new plant. Yet this rule is entirely false, no matter what the definition of net earnings may be.

A correct solution of this problem was given by the editor in our issue of July 14, 1915, but, as it was somewhat buried in an article entitled "A Rational Method of Calculating Depreciated Value," it seems wise to outline a solution of the problem again and to discuss more fully the reasoning upon which it rests.

As between two plant units the choice obviously falls upon the one that yields the greater profit over a term of years. But when one of the two plant units is already owned and in service, while the other must be purchased new, it is not obvious at once that in calculating the cost of the product, the original cost of the old plant unit has nothing whatever to do with the case. This is the first logical pitfall. The second pitfall is encountered when the element of depreciation is reached, for it has never been perceived that, in order to solve the problem correctly, natural depreciation must be entirely separated from functional depreciation and that the latter must be treated precisely as if it were an item of insurance. Natural depreciation is the loss of value due to the action of the forces of nature; whereas functional depreciation is due to invention, growth of business that renders a plant inadequate, and other social forces. In calculating the annual cost, natural depreciation should be classed with repairs, for that is what it is in essence. But on the other hand, a functional depreciation annuity should be classed with a fire insurance premium—an element to be provided for by an annuity based on past experience covering many instances. This distinction is vital. Having ascertained from a study of the history of many plant units of the same general class what the average functional life of the given plant unit may be expected to be, it is a simple mathematical matter to determine what percentage should annually be allowed as the functional depreciation rate (F).

For, for any given new plant unit, we may express the annual profit derivable from it, thus:

(1) $P = G - K$

P = annual profit.
G = annual gross income.
K = annual cost.

If we use capital letters for the new plant unit and lower case (small) letters for the old plant unit, we have for an old plant unit:

(2) $p = g - k$

If the new plant unit and the old one are equally profitable:

(3) $P = p$, or
(4) $G - K = g - k$

If, as is ordinarily the case, the gross income is not altered by substituting a new plant unit for an old one, then $G = g$, and:

(5) $K = k$

Let

E = Annual operating expenses (including repairs and taxes) equated during the estimated economic life of the new plant unit.
e = Ditto for the old plant unit during its remaining economic life.
C = First cost of new plant unit.
S = Salvage value of new plant unit.
s = Ditto of old plant unit.
r = Interest rate, including any risk insurance not covered by F or elsewhere.
F = Functional depreciation rate (not including depreciation from natural causes, such as wear and tear, rot, etc., which are covered by "repairs").

Then

(6) $K = E + (C - S) F + r C$

Only a little study is needed to make the truth of Equation (6) evident; but much more study is ordinarily required to make it evident that Equation (7) is equally true.

(7) $k = e + r s$

To almost every one it has seemed essential that the equation of annual cost for an old plant unit should contain the same number and kinds of terms as for a new plant unit. Here it is that the reasoning process must be carefully scrutinized. Why does the term $(c - s) F$ vanish in Equation (7)? Because $c = s$. Why so? Because, the condition that is tacitly assumed when $K = k$ is that the old plant unit has depreciated and can therefore be purchased at a depreciated value (c), which value (c) can be no greater than its salvage value (s) if the time to retire the old plant unit has arrived.

A more elegant, but more elaborate, process of reaching the same conclusion is given in the article above referred to (our issue of July 14, 1915). There are several other ways of indicating the correctness of the above reasoning as to Equation (7).

Suppose, for example, the choice between a new and an old second-hand machine were in question, and that each could be bought in a market. Suppose the market price of the old machine were little above its scrap value. Then it would be perfectly clear that Equation (7) would give the annual cost of production with the old machine.

Suppose, as another example, that an old machine is owned but that it had been purchased several years ago as a small part of a large second-hand plant, and that the price paid for it is unknown. Would it be rational to insert in Equation (7) a factor c representing its cost to the original owner, even if it were ascertainable? Assuredly not, for that would not be the cost to the present owner, nor would it be any more helpful to attempt to estimate (by prorating) its cost to the present owner when the machine was newer than it now is; particularly if the present owner had paid altogether too much for the entire plant.

Suppose, as a third example, that the present owner of a plant has received it as gift or as an inheritance, and that therefore the cost of the old plant unit to him has been nil. Should c then be made o? Clearly not, for the owner is not concerned with the original cost to him, which is in this case nothing, but with its present cost of replacement, or its true market value. This, under the assumed condition of expired economic life of the old machine, is its salvage value (s).

Since $K = k$, we have:

(8) $E + (C - S) F + r C = e + r s$

This is the equation of condition by which to judge whether an old plant unit has just reached the age of retirement, assuming the gross-income from both new and old plant units to be identical. When the gross-incomes are not identical, the method to be pursued is now self-evident. When the new plant unit is economically superior to the old, there results an inequality:

(9) $E + (C - S) F + r C < e + r s$

Now a few words as to F. This factor, namely, the annual rate of functional depreciation, is perhaps the factor most likely to puzzle those who have not studied the different kinds of depreciation and their economic significance. Functional depreciation is the loss of value due to obsolescence and economic inadequacy. Average functional life is the term of years that a plant unit of the given class remains in use before it is superceded by an improved or larger unit. The functional depreciation rate is the annuity rate which compounded at the interest rate (r) will yield an amount equal to unity at the end of the average functional life.

Another expression requiring explanation is "equated annual expense." As here used, to equate means to secure an economic average by a sinking fund method of calculation. To equate annual repairs, for example, calculate the total cost of repairs of the first year at compound interest up to the end of the last year of economic life of the given plant unit. Calculate similarly the total cost of repairs of the second year, the third year, etc., up to the end of the last year of economic life. Add all these compounded repair costs together and multiply by the annual deposit in a sinking fund which if started at the beginning of the life will redeem $1 at the end of the economic life of the given plant unit. The product is the equated annual cost of repairs. Of course if repair expenditures are uniform, they automatically equate themselves, but this is rarely the case.

Since it is commonly believed that a new plant unit must show an increased profit sufficient to pay interest on the original cost of the old plant unit that it displaces, it is well to point out the fallacy. This is a fallacy of confusion of a general class of improvements with a particular improvement. Progress costs money. Functional depreciation is a loss of value due to progress. Hence it is the cost of progress. But progress implies increasing profit, which must be at least sufficient to equal the functional depreciation. In other words, the profit from progress in general must pay for the cost of progress in general.

Now comes the curious mental twist by which this truth is distorted into an error, thus: The profit from each individual instance of progress must pay for the cost of that particular instance of progress. Whence naturally follows the blunder in the final conclusion that every new plant unit must be sufficiently efficient to pay not only its own individual interest charges but those on the original cost of the plant unit that it displaces. As previously pointed out, a functional depreciation annuity is precisely like a fire insurance premium. Each is based on the law of averages for a given class of risks. It would be evidently illogical to refuse to erect a new factory building to replace one that had burned, unless the new one would yield an increased profit sufficient to pay interest both on its own cost and on the value of its predecessor. Equally illogical is the reasoning that would make an improved machine bear the interest burden of its obsolete predecessor.

These examples of false reasoning should serve to indicate the necessity of studying the general processes of reasoning in a systematic manner. Nearly every trained engineer can juggle equations with skill and accuracy, but such ability is no evidence of equal ability in the reasoning that should precede the setting up of an equation that correctly and completely embodies all conditions, implied or connoted as well as explicitly stated.

DEFINITIONS OF COST, UNIT COST, DIRECT AND INDIRECT COST, AND OVERHEAD COST.

To persons who have not studied economics, and particularly to those who have not heard or read the testimony in many appraisal and rate cases, it usually seems an easy matter to define cost or actual cost. As a fact, however, the word cost has no fixed meaning, and is perhaps even less definite a term than the word value.

In our issue of Jan. 31 we defined price, value, cost, profit and interest. We shall now give further consideration to definitions of cost. These definitions were written by the editor to guide a lawyer in a public utility case where most of the witnesses had testified to various elements of cost without defining any of the cost terms used. Nearly every witness, including a well known professor of political economy, seemed to assume that the word cost is so well established as to require no definition when using it in a rate case. But scarcely any two of the witnesses were talking about the same things when they spoke of "cost," "overhead cost," etc.

One of the commissioners who heard the case was quite impressed by the statement of one witness that "actual cost of the property" should be used as the basis for calculating fair rates of charge for services. The witness argued that "values" and "cost of reproduction" were subject to individual judgment, and, inferentially, were untrustworthy, whereas "actual cost" was a matter of record and not to be disputed. Commenting on this testimony the commissioner said:

> I think you are surely right to this extent: that when you are dealing with cost you are considering a fact which is there, and

> when you are dealing with replacement cost you must accept very much of theory.

Now this commissioner was exceptionally well read, had been a judge and a state governor, as well as a man of business affairs. To him "cost" was "a fact which is there"—just as the chair that he sat in was a fact that could be proved by touching it. But before the testimony was finished he must have begun to doubt his own statement, for different witnesses submitted six different figures of "actual cost of the property" and as many more different figures of "cost of reproduction." Furthermore—and this is our chief concern now—there was as much "theory" in determining the "actual cost" as in determining the "cost of reproduction"!

One of the witnesses, under cross-examination, said:

> I want to explain what I meant by actual cost. I think there are possibly three definitions, three senses in which the term actual cost might be used. One might be book value. Another might be the original cost of the units originally installed. Another would be the actual cost of the units at present in place. It is the third that I have in mind.

This witness did not more than begin to enumerate the meanings that may be given to the term "actual cost of the property." For example, is not what the present holders paid for the stocks and bonds the actual cost of the property to them? Is not the cost of the original plant plus all the "sacrifice costs" (e. g., deficit in fair return) the actual cost to the original owners? And if some of the original owners still own part of the property, while some owners are new, what is the actual cost to all the present owners? What part of an interest charge on the investment is cost and what part is profit? These and many other questions may rise for answer in a rate case involving "actual costs."

The following are five broad definitions of cost terms:

Cost of production includes money outlays, debits incurred, proprietary losses of normal income and compensation for risks involved in production.

Cost may be divided into two classes of business debits:

1. Debits of the business to others than the proprietor.
2. Debits of the business to the proprietor.

In well kept ledgers all of the first-named class of costs will be found, either as property costs or as operating expenses, but it frequently happens that not all—and sometimes not any—of the second class of costs are entered in the ledgers.

Costs of production may be divided into two parts:

1. Direct costs.
2. Indirect costs.

Direct Costs are those costs directly assignable to a group of similar units of product without prorating.

Indirect Costs are costs that cannot be directly assigned to a group of similar units, but must be prorated among different groups of units.

Unit Cost is the cost per unit of product, and is determined by dividing the total cost assigned to a group of units of product by the total number of units.

A unit cost includes all the direct costs and it may include all or nearly all the indirect costs, depending upon the method of accounting or cost analysis.

In appraisal work, as well as in estimating the cost of projected work, it is customary for engineers to use unit costs that include only part of the indirect cost, the remainder of the indirect cost being called "overhead cost."

Overhead Cost is that part of the indirect cost not included in the unit costs.

No hard and fast line can be drawn between unit cost and overhead cost. It is entirely a matter of more or less arbitrary definition. If a company does its construction work by contract, the contractor's **unit prices** are the company's **unit costs**; but the contractor's unit prices includes all of **his** overhead costs. Hence, if a company does its construction with its own forces, its overhead costs will ordinarily be greater than if it does its work by contract, due to the differences in accounting.

In a later issue these terms and others of similar character will be discussed at greater length.

LOGIC FOR ENGINEERS.

The series of articles bearing this title, the second one of which appears in this issue, seems likely to call forth comment from many readers. Already the editor has received a number of letters from readers, most of whom request that their letters be not published. Unless a definite request not to publish a letter is made, it will be published, provided its publication seems to offer an opportunity to clear up an obscurity or eradicate a difference of opinion. One such letter, with an editorial reply, appears in another column and others will be heartily welcomed.

The editor lays no claim to infallibility, even in conclusions upon subjects to which he has given long and careful thought. In fact, he has come to see that even some seemingly obvious matters hide considerable complexity beneath their garb of apparent simplicity. A good example of this fact will be found in this week's leading editorial entitled "When Is It Profitable to Retire an Old Plant Unit?" Here is a very old, very common, and seemingly simple problem in economics. The editor "solved it" many years ago—as he thought—and published the solution in his "Handbook of Cost Data." Two years ago he discovered that he had solved it incorrectly, and he came upon the correct solution in the course of his reasoning upon a seemingly different problem, namely, the problem of ascertaining accrued depreciation or depreciated value.

There are two common depreciation formulas, "the straight line formula" and "the sinking fund formula," about the respective merits of which there has been much argument. The first of the two never gives a precisely correct answer, under any condition, and is often wide of the mark. The second is never right, except under a special condition that is rarely present, namely, when no functional depreciation is involved and when the current repair expenses are uniformly the same year after year. These facts the editor established and afterward published in "E. & C," July 14, 1915. They were established only after long and painstaking study of the logical processes involved in arriving at values in general and depreciated values in particular. Nor has anyone yet offered a demonstration of the inacuracy of the "unit cost or rational depreciation formula."

Mention is made of these facts at this time, not for the purpose of gaining general acceptance for a relatively new method of calculating depreciated value, but to gain acceptance for a much more important generalization, namely:

The errors involved in applying mathematics are rarely errors of numerical manipulation, but are nearly always errors in the reasoning upon which the quantitative statements are based.

There is no novelty in this generalization, but it has nevertheless not "sunk deep" into the minds of some engineers—altogether too many, we fear. Let it once sink even slightly beneath the eyes and there will be much more study of logic among engineers than there ever has been in the past.

THE CAUSE OF THE DURABILITY OF CEDAR AND SOME SUGGESTED USES OF CEDAR.

Rotting of timber is due to the growth of fungus that feeds upon the wood. Moisture and warmth are essential to the life of any fungus. There are few kinds of wood that are serviceable longer than ten years when exposed to moisture and to warmth. Cedar is exceptionably durable, even under the most adverse conditions, as when embedded in damp soil.

The reason for its durability is found in the fact that it is impregnated with oil of cedar, which, like creosote, is a deadly poison to rot fungus. Oil of cedar, however, appears to be somewhat more volatile than creosote, or more readily changed in chemical composition by exposure. But it is very noticeable that in some climates cedar shingles, etc., are almost indestructible. For example, a few years ago an old Indian fort near Bellingham, Wash., was torn down. The cedar "shakes" that formed the roof of the fort had been worn very thin by the rain during their 40 years' of existence on the roof, but showed no sign of rot. Even more remarkable examples of the durability of cedar are found in the same Puget Sound region. The writer has seen a 3-ft. cedar log straddled by the roots of a fir tree of equal diameter. The big fir had grown over the fallen cedar, and its period of growth had probably been more than a century, yet the fallen cedar had rotted only a few inches deep and was sound enough to be sawed into shingles which themselves might have roofed a building for another half century.

On the other hand, a building contractor of Buffalo, N. Y., told the writer that cedar shingles from the state of Washington seldom lasted more than 8 or 10 years in Buffalo. The reasons for this short life are probably two: First, improper kiln drying of the shingles doubtless evaporates or destroys most of the oil of cedar, and even careful kiln drying may remove some of this preservative oil. Second, the dry climate and hot summer suns of western New York may be worse than kiln drying in their effect upon the cedar oil in thin shingles.

In passing, we may remark that it might pay well not to kiln dry cedar shingles at all, or but very slightly; for the money paid in freight on the water in the pores of the cedar might be money well spent in securing a longer life for the shingles.

The writer erected a large number of electric light cedar poles at Bellingham, Wash., twenty years ago, and they are still in service. They were originally painted, but the paint has long ago peeled off, and never served any useful purpose other than to make the poles appear better when they were first erected.

The writer also floored some highway bridges with cedar plank, which was still in good condition 12 years later when the bridges were taken down because the fir trusses had decayed. In the writer's opinion cedar is not used as frequently in bridge and trestle work as it should be. While cedar piles will not stand very hard driving, there are innumerable places where the driving is easy and where cedar piles can be used. Incidentally, it may be added, cedar piles are very durable, even in sea water where the teredo exists.

Probably one of the reasons why cedar plank has not been more frequently used for highway bridge flooring, for plank roads, etc., in the Pacific Northwest where cedar is cheap, is because the softness of the cedar has deceived people into thinking that wagon wheels would soon destroy it. The surface of cedar plank is splintered by wheels and hoofs, but, curiously enough, the splinters form a sort of mat that protects the body of the plank from further wear. Certainly where the traffic is moderate, cedar plank makes a more durable roadway than any other kind of timber.

Finally, the thought suggests itself that the oil of cedar might be distilled at a low cost from cedar boughs and small cedar trees and might be used to preserve other woods, just as coal tar creosote is now used. Indeed, if this should prove economically feasible, cedar trees might eventually be planted where other crops would not be profitable, and the young cedars might be used as a source of supply of the oil that is such an effective wood preservative. Oil of cedar thus secured might be more costly per gallon than creosote, and still be a cheaper preservative, for it takes very little oil of cedar per cubic foot of wood to effect its preservation.

HOW TO TAX "FIRE TRAPS" OUT OF EXISTENCE.

The annual maintenance and operation of American city fire departments costs about $1.50 per capita as contrasted with 20 cts. in Europe, and our fire losses amount to antoher $1.50 per capita. Since fire insurance companies collect $2 in premiums for every $1 paid out for losses, and since the interest and depreciation of the plant used by city fire departments is not included above, the total per capita cost attributable to fires is probably not less than $5. A very large part of this expenditure can be saved by erecting better buildings. To encourage the removal of fire-traps, how would it do to tax all buildings directly for the support of city fire departments? If this was done and the tax prorated according to fire insurance premiums, it would cease to be profitable to maintain fire-traps or even fire inviters.

EDITORIAL COMMENT.

Building permits issued in the 40 largest cities in America during 1916 amounted to $800,000,000 in round numbers, or almost exactly double the total for 1903. Higher prices of building materials account for part of this increase, but, even allowing for that, the growth of the building industry in this country has been phenomenal. Greater wealth spells greater and better buildings, so there is no likelihood that any permanent halt in this line of structural progress will occur.

In patching old concrete with new, it is not generally known that hydrochloric acid is very helpful in securing a good "weld." The old concrete should be brushed, then washed with dilute hydrochloric ("muriatic") acid. The acid should next be washed off with water and a neat cement grout applied. Then the old surface is ready to receive the new concrete. Some years ago the editor saw some test bars of concrete that Mr. E. L. Ransome had thus "welded" together—an old piece on which a new piece had been cast—and was amazed to find that when broken transversely the break did not occur at the joint.

A 47-year-old iron railway bridge (consisting mostly of Fink trusses) across the Ohio River at Louisville, Ky., is about to be taken down because it is too light for present wheel loads. During its entire life it has had almost no repairs, except of the floor system, and has been painted but three times since its erection. Repainting every 10 to 12 years entirely prevented pitting of the iron. All coats were of red lead and oil that was boiled just before mixing. This unusual record of the useful life of paint on a bridge may be in part due to the paint itself. But may not the fact that the bridge was of iron instead of steel account in a measure for the long life of the paint?

A CRITICISM OF "LOGIC FOR ENGINEERS" AND A REPLY.

To the Editor: In your article on Logic in Engineering and Contracting of Jan. 31 there are two defects which I wish to call to your attention and the attention of your readers.

The first defect is the lack of historical perspective you show when you attack Kant, who lived 150 years ago. Why not as well prove to us that Newton said several things which are wrong?

Considering that the whole modern philosophy and psychology is only 300 years old and that Kant is a very important but rather distant link in the evolution of modern thought, why not let him sleep in peace on the glory he won by deepening and clarifying the philosophy, as it was, when he was young?

The other defect is the statement:

"Experience is an arrangement of the atoms of the brain," etc.

I assume that you mean: Experience **corresponds to** "an arrangement of the atoms of the brain," etc., and expressed this way it is acceptable to everybody who adheres to the belief that mind and matter are two manifestations of the same fundamental existence and therefore correspond to each other in a way we as yet cannot explain. But as expressed by you without any previous mentioning of mind at all it must be misleading for those of your readers who have no philosophical training, and distasteful to those who have.

C. L. Christensen,
Designing Engineer Niagara River Bridge, Michigan Central Railroad.
Detroit, Mich.

[Our correspondent objects to a criticism of Kant on the ground that it is unnecessary to speak critically of a writer who lived 150 years ago. In the last edition of the Encyclopedia Brittanica, under Psychology, Kant's theories are often commented upon with favor and occasionally otherwise. Herbert Spencer, Mill and indeed almost every writer on philosophy and logic since Kant's day has had a great deal to say about Kant's ideas, and the end of the saying is not yet for Kant was a thinker of such originality and force that his writings will probably be discussed a century hence.

The second defect, according to our correspondent, consists in stating that "experience is an arrangement of the atoms of the brain," instead of stating that experience "corresponds to" such an arrangement. Every record produced in the brain through the senses is a sense-record that can be conceived or "pictured" in no other way than as being a certain peculiar atomic, or perhaps corpuscular, arrangement. If this is a correct interpretation of the significance of experience, then it is proper to say that experience is such an arrangement. If, on the other hand, experience is something else than such an atomic or corpuscular arrangement, then it may be proper to say that experience "corresponds to," instead of is, such an arrangement. But if this is so, it devolves upon us to signify not only what is meant by the vague expression "corresponds to," but to indicate in what manner there is a correspondence between the the atomic constitution of the brain and the supposedly "external" thing denominated "experience." If, however, we can not frame a mental picture of the "correspondence" between an "external" experience and an "arrangement of the atoms" of the brain, let us confess the inability at once, and not try to cloak our ignorance with vague words such as the words "corresponds to." Nothing is elucidated by using language in such a manner. On the contrary, much of the muddled reasoning that exists in the world is directly traceable to just this kind of misuse of language.

John Locke, 230 years ago, in his justly celebrated "Essay on the Human Understanding," said:

> A man should take care to use no word without a signification, no name without an idea for which he makes it stand.

He harped upon this thought in many tunes, but there will always remain need for such harping. We may now add somewhat to Locke's important generalization, giving it a still more general and wider utility:

In reasoning, no word or term should be used except as a symbol, or part of a symbol, of a definite sense-record or feeling-record; and then only when the word or term introduces no incongruity or conceals no ignorance.

Unfortunately, this brief discussion is out of the order that the editor has planned for his articles on logic. The terms "sense-record" and "feeling-record" are somewhat elucidated in the second article on Logic in this issue, and will be more fully discussed in later articles, as will also the subject of words as symbols of sense-records and feeling-records.—Editor.]

HYDRATED LIME IN BOSTON NAVY YARD CONCRETE SPECIMEN.

To the Editor:—The very interesting article on pages 74 and 75 of your January 24th issue entitled "Action of Sea Water on Concrete Specimens at Boston Navy Yard" has been read with a great deal of interest.

I note particularly section (e) which states "that hydrated lime was of no benefit, but rather a detriment." While it may be true that specimen No. 22 (containing hydrated lime) is in condition to justify the notes shown in the table accompanying the article, at the same time I do not feel that the conclusion can be drawn that hydrated lime was a detriment. The conditions under which hydrated lime was used in this specimen are rather unusual and should be taken into consideration before any conclusions are drawn.

The mixture from which specimen No. 22 was made was 1-3-6, and it will be noticed that 1/10th of the cement was replaced with an equal quantity of hydrated lime. This is not in accordance with general practice, as in most cases hydrated lime is added and not substituted, even when used with the richer 1-2-4 mix. Why, then, should a test be conducted involving hydrated lime and use the lime in accordance with conditions other than general practice?

We have in our office a letter from Mr. H. L. Sherman, President of the New England Bureau of Tests, who cooperated with the Aberthaw Construction Co. in outlining this particular test, dated May 25, 1915, which reads, in part, as follows:

> It is my belief that we used too small a percentage of hydrated lime in the specimen in which this was used and the results have not been entirely satisfactory. As you will note on page 29 of the pamphlet to which you refer, this was quite a lean concrete, and it is my belief that if we had used enough hydrate our results would have been much better.

Again, it will be found by examining the bulletin issued in 1914 by the Aberthaw Construction Co. entitled "Aberthaw Test on Concrete in Sea Water" that specimen No. 22, containing hydrated lime, was cracked when it was first submerged in February of 1909, and that when this specimen was examined March 3, 1910, water was found to be leaking out of this crack.

In view of all the above, it would seem to the writer that before any true conclusion can be arrived at relative to hydrated lime that it will be necessary to conduct an investigation with the specimens made up to meet more nearly practical conditions and to take all conditions into consideration when arriving at the conclusion.

Hydrated lime is being used in many operations where it is not subjected to the action of sea water, and is performing most effectively, but if a condition should arise where hydrate is expected to do too much, or to carry too much of a load, which seems to be the case in the above, then in all probability it will fail just as it has done in this sea water investigation. On the other hand, there seems to be no evidence that when hydrated lime is used in concrete exposed to sea water, and the hydrate is used in accordance with general practice conditions, it will not perform in the same satisfactory manner that it is when used in all other concrete.

Taking into consideration these conditions, we cannot see wherein a statement is justfiable that hydrated lime was a detriment.

Hydrated Lime Bureau,
Norman G. Hough, Manager.
Pittsburgh, Pa.

ARCHITECTURAL MONUMENTS AND PUBLIC BUILDINGS.

To the Editor: The Buildings and Structural issue of Engineering and Contracting of Jan. 24, 1917, in the article entitled "Give Us Fewer Architectural Monuments and More Engineering Structures for Public Buildings," on page 1, lacks that fairness, accuracy, and painstaking completeness which is the usual characteristic of your comments. The writer of the article will have to shelter behind words such as "average" and "nearly" to escape the accusation of an absolute mis-statement in his positive conclusion that monumental buildings cannot follow architectural precedent and at the same time achieve in full measure the requirements of a modern office building. This conclusion is not borne out by facts. We will point you one example:

The Northwestern Mutual Home office building in Milwaukee, built by us, is a monumental structure strictly following classic precedent. In matters of percentage of windows and glass area, angle and distribution of light, namely, illumination, it surpasses the average office building.

In matters of efficient application of space, direct communications, easy circulation, and similar items of office space, lobby, corridor, and stairway treatment, it follows the most modern office building practice. In matters of sanitation and ventilation it surpasses anything we know of in an office building for rental purposes.

The entire building, including all office space, is forced fan-ventilated, using induction and eduction systems of fan-handled air, with provision for future air refrigerating. The heights of ceiling give a percentage of cubic contents per room occupant that would scarcely be attempted in a commercial building.

The arrangement, distribution, lighting, ventilation and sanitary precautions which have been applied to the toilet rooms in this building would be a difficult precedent for an architect to follow in the arrangement of a revenue producing office building.

The interior of this building carries all the advantages of—in fact, is almost identical in appearance with—a modern office building with somewhat more ceiling heights, air and light, and the exterior speaks for itself as a full monumental structure. Viewed strictly as an office building it is the best we know of.

Your article is correct in its assertion that most monumental buildings are not really fitted for their purpose, but this is not because it cannot be done within the limits of monumental architecture precedent. Since precedent is largely lacking, this problem can be solved by men who can add an imagination to technical ability; more of the architect and less of the engineer, but some of both. Until precedent has given something from which to copy, lacking imagination, the designer will fall short of the full combination result whether he be engineer or architect.

Your publication is a pleasant relief from the usual magazine inaccuracies.

Get right on this.

Marshall & Fox,
Architects and Engineers.

Chicago, Ill.

COST OF BRIDGE CONSTRUCTION IN WISCONSIN IN 1914 AND 1915.

Bridge work in Wisconsin cost less in 1915 than it did in 1914, according to figures in the recently issued third biennial report of the Wisconsin Highway Commission. Table I, compiled from the report, shows details of the state aid and county aid bridge construction in 1914 and in 1915. The county aid bridges are built in accordance with plans furnished by the State Highway Commission, the necessary money for construction being furnished from town and county funds. The bridges were evidently built, or the materials were contracted for, before the great advance in steel prices, which began in the fall of 1915.

TABLE I—COMPARATIVE COSTS OF WISCONSIN BRIDGES IN 1914 AND 1915.

	State aid bridges.		County aid bridges.	
	1914.	1915.	1914.	1915.
Reinforced concrete slab and girder bridges:				
Number built	136	111	71	92
Total length, ft.	1,380	1,840	1,171	1,363
Concrete, cu. yd.	6,451	8,305	5,038	6,501
Steel, lb.	346,410	502,980	320,110	369,610
Cost per ft.	$48.80	$48.00	$49.40	$54.50
Concrete, per cu. yd.	$10.40	$10.65	$11.50	$11.40
Reinforced concrete arch bridges:				
Number built	2	5	5	1
Total length, ft.	292	302	56	16
Concrete, cu. yd.	2,114	1,715	421	166
Steel, lb.	231,350	85,820	20,570	10,380
Cost per ft.	$133.70	$75.90	$92.80	$112.50
Concrete, per cu. yd.	$18.50	$13.40	$12.35	$10.85
Steel I-beam bridges:				
Number built	138	119	228	201
Total length, ft.	2,900	2,688	1,963	4,403
Concrete, cu. yd.	9,260	8,155	14,145	13,462
Steel, lb.	1,085,710	1,114,670	1,878,590	1,706,470
Cost per ft.	$36.20	$35.60	$38.20	$39.20
Steel truss bridges:				
Number built	21	23	29	18
Total length, ft.	1,694	1,973	2,494	1,515
Concrete, cu. yd.	3,371	3,421	4,563	3,002
Steel, lb.	992,630	1,169,940	1,506,430	877,650
Cost, per ft.	$37.30	$33.00	$37.10	$33.70
Steel plate girder bridges:				
Number built	21	22	11	27
Total length, ft.	1,384	2,092	605	1,415
Concrete, cu. yd.	2,716	3,785	1,484	3,564
Steel, lb.	836,270	1,249,940	321,210	743,320
Cost per ft.	$35.60	$31.30	$38.40	$38.50

LOGIC FOR ENGINEERS.

II. The Senses and Feelings.

By Halbert P. Gillette.

[The first article of this series was published Jan. 31. Its subtitle was "Energy and Cause-Effect."]

Primary Sources of Knowledge.—In the last article it was shown that the subject matter of all reasoning is energy and its categories—number, time, space and mass. In this article it will be shown that the primary sources of all knowledge of "external nature" are the five sense organs.

The senses are nerve organs that receive and transmit certain classes and intensities of energy to nerve ganglia the largest of which is the brain. The nerve ganglia "record" the energy waves thus transmitted. These sense-records constitute what we call experience or knowledge. In a later article the nature of sense-records will be discussed at length, and it will be shown how the different processes of reasoning consist entirely in forming sense-records and replaying them in different combinations. This much of a foreword seems desirable, in order to indicate the ultimate utility of the present article of the series, which otherwise might seem lacking in direct applicability by a student of logic.

The Five Senses.—Although the different classes of energy-groups are so numerous as to balk the memory and stagger the imagination, yet the myriad kinds of things outside the human body have only five known speaking tubes through which they may announce themselves to the mind, namely the senses of (1) touch, (2) sight, (3) hearing, (4) taste, and (5) smell. A sixth sense, that records temperature changes, is believed to exist, but the sense of touch seeems to be a complex sense that reacts both to mechanical pressures and to the molecular vibrations that constitute heat. Therefore, until it is definitely proved that there is a distinct set of organs for receiving heat vibrations, it seems better to regard the sense of touch as a sense that reacts to heat as well as molar motion. Touch, then, may be called a mechanically actuated sense. Hearing also is mechanically actuated, but only by means of certain forms of wave motion that pass through gases, liquids and solids to the ear. Sight may be called the ethereal wave sense, since it is actuated by the impact of waves of ethereal corpuscles, called light.

Taste and smell are chemically actuated senses. Substances in solution produce chemical changes in the nerves of these two senses, and the resulting changes are called taste or smell, depending on whether the change occurs in the mouth or in the nostrils.

Of the five senses, the sense of touch is the only one that is widely distributed over the body. This fact, coupled with the fact that the lowest forms of life seem to possess no other sense than that of touch, confirms the belief that in the evolution of life the sense of touch was the primal sense. Furthermore it is probable that the other four senses were evolved from the sense of touch. In the next article it will be shown that the sense of touch is the only sense that creates sense-records from which all four categories of energy can be derived.

Although the five senses react to external energy, it does not follow that any one of the senses need be affected by more than one kind of energy; nor is it necessary that even that one kind of energy be sensed throughout its entire range of intensity. The eye, for example, reacts to only one general class of energy, which is termed light, but there are "light waves" that the eye does not see at all.

The following quotations from the Encyclopedia Britannica are of interest:

> Touch: It would appear that touch is always the result of variation of pressure. No portion of the body when touching anything can be regarded as absolutely motionless, and the slight oscillations of the sensatory surface, and in many cases of the body touched, produce those variations of pressure on which touch depends. . . There is every reason to hold that there are different nerve fibers and different central organs for the tactile and thermal sensations, but nothing definite is known. . . . No thermal organ for dis-

crimination of temperature has yet been found. It will be observed that the sensation of heat or cold is excited by change of temperature, and that it is more acute and definite the more sudden the change. Thus discrimination of temperature is similar to discrimination of touch, which depends on more or less sudden changes of pressure.

Taste: Evidence is accumulating that taste depends on nervous impulses excited by chemical changes. . . . The sensation of taste may also be excited mechanically, as by smartly tapping the tongue, or by the stimulus of a continuous [electric] current.

Smell: The free olfactory surface is always covered with a thin layer of fluid, and all odoriferous matters must be dissolved in this fluid so as to reach the rod-cells. There is here an analogy with the conditions found in the sense of taste, where sapid substances must be soluble in the fluid of the mouth. . . . Ramsay points out that as a general rule substances having a low molecular weight have either no smell or simply cause irritation of the nostrils. . . . To produce the sensation of smell a substance must have a molecular weight at least fifteen times that of hydrogen. . . . It has also been pointed out by J. B. Haycraft that chemical compounds of elements belonging to the same group, according to the well-known periodic law of Mendeleeff, have sometimes odors of a similar character.

Nerve-Stuff.—Animal matter of every sort is a colony of cells or minute living units. Among these cells is a class of cells so constituted chemically that slight vibrations alter the chemical combination. These chemically unstable cells constitute the nerve-stuff. When a group of cells consist mainly of nerve-stuff, and when they are arranged in thread-like form, they constitute a nerve. An enlargement of a nerve, forming a bunch of nerve-stuff, is called a ganglion. The brain is a great group of ganglia.

The primative or original nerve-stuff, from which the five senses have evolved, undoubtedly is an organic chemical combination that is readily broken up when the pressure upon it changes. Hence the sense of touch is a sense that registers changes of stress in the nerve-stuff. From this primative nerve-stuff there have evolved certain forms of nerve-stuff in which chemical changes are effected by certain peculiar forms of energy. Thus the retinal nerves of the eye are chemically changed by the energy of light, the change not being necessarily direct but probably through a mediate chemical change in the substance of the retina.

The mechanism of the ear has been evolved to amplify the effect of sound waves, resulting in impacts upon the auricular nerve sufficiently intense to change it chemically and cause a chemical wave to travel to the brain.

The chemical waves that reach the brain through the different nerves cause chemical changes in the brain itself. When these changes are more or less permanent, they may be called sense-records.

The Feelings.—Some psychologists enumerate 12 or more senses. In addition to the five above given they name the senses of (1) warmth, (2) cold, (3) strain, (4) dizziness, (5) pain, (6) pleasure, etc. The first two of these should be classed as one, namely the sense of temperature, which we have already discussed as a sense of touch. A "sense of strain" is probably nothing else than a sense of touch also. Dizziness, pain and pleasure are not senses. They are feelings.

When one of the five senses is in operation, a sensation is experienced. But it is not wise to call a sensation a feeling. One has a sensation of redness, for example, but not a feeling of redness. The word feeling should be restricted to a pain or pleasure of some kind or degree.

A reasoner should have clearly in mind the distinction between sensations and feelings. Sensations indicate the normal functioning of the organs of sense. Feelings, however, are consequent upon departure from a uniform functioning of cells in the body, moreover, feelings are not restricted to the five organs of sense.

In a later article it will be shown that feelings often block reasoning and cause precipitate action. Sensations never directly cause precipitate action; indeed they frequently obscure feelings and lead to inaction.

Although it is impossible truly to "explain" either a sensation or a feeling, since it must be sensed or felt to be fully understood, it is possible to indicate the conditions that result in a sensation or a feeling of a given kind. One may state, for example, that a flame in contact with the skin causes a feeling of pain, which may be distinguished as a "burning pain." Similarly it should be possible to ascertain the most general condition that applies to every kind of pain.

Philosophical reasoners long ago stated that severe pain is associated with a change that is injurious to the animal organism; but they seem to have been puzzled by the fact that mild pain, such as the incipient gnawings of hunger, is beneficial to the animal organism because it leads to an attempt to secure relief from the discomfort. Terrible pain often is the immediate prelude to death; mild pain is usually a prelude to renewed life. So the paradox is by no means easy to penetrate.

Based partly on ideas already established and partly on my own reasoning, the following philosophy of pain and pleasure is offered.

Pain.—Every living cell capable of responding to a stimulus is in a state of continuous change. The change is both chemical and physical. The changes are rhythmic in character, as Spencer pointed out, and this doubtless is due primarily to the fact that the physical changes on the earth are rhythmic. Thus the revolution of the earth upon its axis causes a daily cycle of light and heat change, in consequence of which every living organism on the earth undergoes a diurnal change. Similarly the annual sweep of the earth around the sun causes a cyclic temperature change that affects living things.

Living cells have become "habituated" to these rhythmic or cycle changes. Just how this formation of cell habits is secured we do not yet know; but we do know that every living thing has habits, which means that its actions accord with the changes in external energy to which it is subjected. Since these external changes are cyclic and approximately uniform in their rhythm, the cell habits, or changes, are also rhythmic.

If any living cell is removed from its accustomed cyclic or rhythmic environment and subjected to different conditions, the cell must either form new habits or die.

The incipient death of a cell upon failure to live its accustomed rhythm or cycle change is accompaned by pain.

There are infinite degrees of pain, from mild discomfort to excruciating agony, but every degree of pain initiates an effort to escape its cause, which is tantamount to seeking a restoration of the accustomed rhythm of energy conditions. Pain, then, is a signal of cell death; but of course this is not always equivalent to death of the entire colony of different kinds of cells that constitute a living animal.

All appetites are of the pain character.—The appetites of all primitive forms of animals drive them to action. Even among the higher animals, discomfort—which is mild pain—is the great stimulus to action. Suppress rhythmic cell change, whether by removal of or failure to supply some essential chemical, or by an unaccustomed change of temperature, or by preventing excretion of dead cells, or in any one of numberless ways, and there results a pain of some kind.

Pleasure.—Pleasure is occasionally spoken of as "negative pain," but the term is unfortunately chosen, for negative means either absent or in the opposite direction. Pleasure is the antithesis of pain, but what does that mean? If incipient death of a cell is accompanied by pain, is incipient restoration of life accompanied by pleasure? Undoubtedly. Hunger is a pain that gives way to pleasure when proper food is secured. Weariness is a pain that yields to the luxury of rest after exertion. Yet prolonged rest itself becomes irksome because certain cells begin to crave the renewal of their habituated rhythm of action.

Pleasure is a feeling attendant on the return to an accustomed rhythm of cell action after an interruption in the rhythm.

The longer the abstinence from the accustomed rhythm, the keener the pleasure upon the renewal of the accustomed cell activity, provided the abstinence is not so prolonged as to amount to a breaking of the cell habit. Pleasures, then, are consequent, first, on the formation of a rhythm or habit, and, second, on the occasional prolongation of the intervals in the rhythm.

These generalizations have several important corollaries. For example:

It is impossible to desire anything that has not become a rhythmic action, through inheritance or personal experience.

The more deeply established the rhythmic habit, the greater the pain consequent upon its cessation, and the greater the pleasure consequent upon its renewal.

When chemical action in a living cell occurs according to its rhythmic habit, neither pain nor pleasure is felt; but when there is departure from the rhythm, feeling is engendered, painful when the cell breaks down, pleasurable when the cell builds up again.

Attempts to increase pleasure through inordinate repetition defeat themselves, leading to pain or to indifference.

There is no "absolute standard" of pain or pleasure, for the kind and degree of each is entirely dependent on the rhythm to which the species and the individual has become accustomed; hence it is idle to debate about the relative intensity of pains or pleasures in different individuals.

Feeling-Records.—I have used the term sense-record to denote the record made in the brain by a sensation. It seems desirable to coin another term of analogous character, namely feeling-record. A feeling-record is an impression or record made in the brain by a feeling. A feeling-record is invariably formed at the same time as some sense-record, and the two are therefore associated in the mind. Thus, a feeling-record of a burn is formed in association with a sense-record of a very hot thing in contact with the skin.

A feeling-record that is revived by the revival of an associated sense-record, is never as intense as the original feeling, but its intensity is sufficient to characterize it as a secondary feeling or emotion.

The Secondary Feelings or Emotions.—An emotion, or secondary feeling, is a revived feeling of pain or pleasure, consequent upon the revival of a sense-record originally associated with the given pain or pleasure. Thus the sight of blood may arouse an emotion of fear, which is a distress that is like the original pain that occured with a loss of blood. Similarly the remembrance of a blow received may arouse an emotion of anger.

Hope is a revived feeling of pleasure consequent upon the revival of a sense-record that was originally associated with a directly pleasurable feeling. Fear is a revived feeling of pain consequent upon the revival of a sense-record that was originally associated with a directly painful feeling.

Emotion causes muscular and other organic action similar to that that occurred during the original feeling of pain or pleasure. Curiously enough, organic action thus caused by emotion, reacts and increases the emotion, and the increased emotion causes further increase in organic action. Thus anger causes a clenching of the fists and a setting of the jaws, which very actions increase the anger. This sort of reciprocal causation is a phenomenon that has puzzled many reasoners. Professor James, for example, contends that organic action precedes and causes emotion, whereas other psychologists reverse the order. Both sides are right, in part, yet neither side has perceived the entire truth, since neither has had any conception of the phenomenon of reciprocal causation. In a later article this subject will be discussed at some length. It must suffice now to give an illustration of reciprocal causation in the physical world. Fire causes a draft of air, and a draft causes a greater fire, which in turn still further increases the draft, and so on.

We have already seen that there is no absolute standard by which to measure direct feelings. The same holds of secondary feelings or emotions. It follows that no two living things experience precisely the same degree of direct feeling or of emotion under the same external conditions. Pleasure and pain, joy and anger, hope and fear, beauty and ugliness, are all without absolute standards by which they may be definitely gaged for all individuals. Each individual has his own "standard," but even that does not remain constant. The old Latin proverb, "De gustibus non disputandum" (about tastes there is no disputing) has, therefore, a generality not dreamed of by its originator.

To convert another man to your feeling about a given thing is impossible of accomplishment by any process of reasoning. Only habit-forming practice in feeling like things can generate similar feelings. Argument can never persuade a Hotentot that a Wagnerian symphony is preferable to the simple rhythm of the tom-tom.

In the most cursory manner we have passed over the fundamental facts about the senses and the feelings; yet even this brief reconnaissance develops several important facts:

First, that all knowledge of "the external world" is conveyed through the senses to the brain; and that the sense-records there formed constitute knowledge.

Second, that feelings, whether direct or emotional, are obstructions to the reasoning processes.

Third, that there is no "absolute standard" by which the intensity of feelings or emotions consequent upon given external conditions can be gaged.

In the next article the categories of energy—number, time, space and mass—will be discussed. I will also point out that every equation expressive of functional relationship resolves itself finally into an expression of equality between different groups of ultimate corpuscles.

THE EULER FORMULA AND EXACT THEORY OF COLUMNS.

Contributed by J. H. A. Brahtz, Consulting Engineer, St. Paul, Minn.

The article by David Kaplan in the February 2, 1916, issue of Engineering and Contracting brings out once more that the true results of the mathematical correct treatment of ideal columns has not yet been generally conceived. Previous articles on the same subject point to the same effect.

See for instance articles by Wm. Cain in Transactions American Society of Civil Engineers, 1897; by Henry S. Prichard in Engineering News, May 6th, 1897; Alois Schneider in Zeitschr. d Oesterr. Ing. -u. Arch Ver. 1901 No. 39-40, and several others.

Owing to this general misunderstanding the writer thinks that a short discussion of the Euler formula and the exact theory of ideal columns might serve well to prevent further attempts to develop new true theoretical expressions. I am here mainly referring to the above mentioned article by David Kaplan.

The fallacy of this article pends on the attempt to integrate the equation:

$EI \frac{d^2y}{dx^2} \doteq Wy$, by the substitution $y = x^n$ where n is assumed constant.

Before briefly developing the Euler formula it should be noted that the following approximations are made: (1) The column is "ideal," which means: (a) That the axis or center line is an absolute straight line. (b) That the load W is centered on and acts along the axis. (c) That the material in the column is homogeneous.

(2) The shortening of the column from the direct compression W is ignored as less important.

(3) The same assumptions are made as in the theory of bending amongst which: (a) Hook's law. (b) A plane section remains plane. (c) Radius of curvature

$$\rho = \frac{1}{\frac{d^2y}{dx^2}},$$

which is only good for small deflections, are the most important.

(4) In determinating the constants the length of the elastic curve is assumed equal to that of the unbent column, the difference being of little importance.

With these approximations the equation for the elastic curve for the column in Fig. 1 becomes,

$$EI \cdot \frac{d^2y}{dx^2} = -W \cdot y \quad \dots\dots\dots\dots (1)$$

(The minus is due to the fact that the concavity is towards the negative Y if y is positive.)

By substituting $y = e^{nx}$

$$\frac{dy}{dx} = ne^{nx}$$

$$\frac{d^2y}{dx^2} = n^2 e^{nx}$$

$$EI \cdot n^2 e^{nx} = -Wy \dots\dots\dots\dots (1a)$$

$$n = \pm \sqrt{-\frac{W}{EI}}$$

The primitive equation is then:

$$y = A . e^{+x\sqrt{-\frac{W}{EI}}} + B . e^{-x\sqrt{-\frac{W}{EI}}}$$

or:

$$y = C \sin \sqrt{\frac{W}{EI}}\, x + D \cos \sqrt{\frac{W}{EI}}\, x ; \dots\dots\dots\dots (2)$$

The special simultaneous values:

$x = 0$, $y = 0$, gives $D = 0$;

and $x = l$, $y = 0$ (neglecting the difference between chord ad arc) gives:

$$C \sin \sqrt{\frac{W}{EI}}\, l = 0 \quad \dots\dots\dots\dots (3)$$

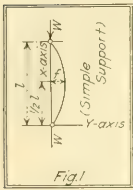


Fig. 1

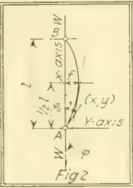


Fig 2

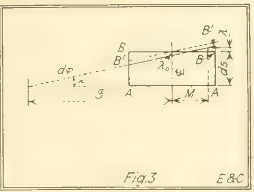


Fig. 3

This equation is satisfied by $C = 0$, which gives the elastic curve:

$$y = 0.$$

Result: The ideal column can remain straight under any load W.

This is obvious when considering the definition of an ideal column. It does not mean, however, that equilibrium cannot exist if by some external force the column is brought out of the "straight" equilibrium. The question can be formulated thus:

Does any such load W exist which can prevent the column from returning to the "straight" equilibrium if once by force being given a deflection?

In this case Equation (2) becomes:

$$y = C \sin \sqrt{\frac{W}{EI}}\, x \quad \dots\dots\dots\dots (4)$$

(D is zero in any case, and C now means the maximum deflection.)

To assume a deflection in the column means to assume C a different value than zero, and it remains then to see if the condition (3) can be satisfied by giving W a certain value. Now letting W continuously increase from zero it is easily seen that Equation (3) cannot be satisfied for any value of W less than:

$$W = W_{Euler} = \frac{\pi^2 EI}{l^2}$$

Result: For $W < W_{Euler}$ there can be no equilibrium except the one determined by $C = 0$, which means that the column will return to the straight equilibrium for any load less than $\frac{\pi^2 EI}{l^2}$.

If $W = W_{Euler}$, Equation (4) becomes:

$$y = C \sin \pi . \frac{x}{l} \quad \dots\dots\dots\dots (5)$$

Where C as above mentioned is the maximum deflection. From this equation we get the curious result that the column will be in equilibrium for any value of C.

This result may seem a peculiar one, but considering the approximations made it can easily be explained, by the fact that deflections of a beam can be found by taking moments, using the actual moment area as the only load on the beam. In the present case the moment curve and elastic curve coincide. So if one position of the column is an equilibrium any position must be it.

Finally it will be seen that

$$W = \frac{n^2 \pi^2 EI}{l^2}$$

Where n is a whole number, satisfies Equation (3).

Equation (4) then becomes:

$$y = C \sin n . \pi . \frac{x}{l} \quad \dots\dots\dots\dots (5a)$$

This sinusoid intersects the X— axis in points $\frac{1}{n} l, \frac{2}{n} l$.

The column can however not be expected to assume this shape without intermediate supports in points $\frac{1}{n} l, \frac{2}{n} l$.

Resume:

The column remains straight for loads $W < W_E = \frac{\pi^2 EI}{l^2}$ which must be considered the ultimate load.

For $W = W_E$ the equilibrium is indefinite.

It must be remembered that the formulae used only hold good within the elastic limit.

The Exact Equation for Deflections in an Ideal Column.

The Euler formula does not give any information regarding the actual deflections of a column, but gives the ultimate load only. In this exact treatment the same assumptions are made as above with the following exceptions:

(1) The radius of curvature here is taken exact and not as $1 : \frac{d^2y}{dx^2}$.

(2) In determining constants the actual length of the arc is used.

(3) The direct compression from the load W is taken into consideration.

In Fig. 2 is shown the column and the designations. Fig. 3 represents an element ds of the column between two consecutive sections AA and BB; when the column deflects these sections get a relative angular deflection of $d\phi$. At a distance η from the axis the elongation of ds is:

$$\lambda = \eta . d\phi - \lambda_0 .$$

λ_0 is the elongation at the axis and therefore determined by the axial load W alone:

The elongation per unit of length:

$$\epsilon = \eta . \frac{d\phi}{ds} - \epsilon_0 ,$$

and the stress:

$$\sigma = E . \eta . \frac{d\phi}{ds} - \sigma_0 .$$

The conditions of equilibrium for any section of the column are:

$$\text{Moment} = M = \int \eta . \sigma . dA \quad (a)$$

$$\text{and} : W = \int \sigma . dA .$$

$$W = \int E \eta . \frac{d\phi}{ds} dA - \int \sigma_0 . dA ;$$

$E \frac{d\phi}{ds} \int \eta . dA$ being zero, (b) becomes

$$W = -\sigma_0 \int dA = -\sigma_0 . A$$

$$\sigma_0 = -\frac{W}{A} = -\frac{\text{Load}}{\text{Sectional Area.}}$$

Equation (a):

$$M = \int \eta . E \eta \frac{d\phi}{ds} . dA - \int \eta \sigma_0 dA. \quad \ldots\ldots\ldots (a)$$

or: $\sigma_0 . \int \eta . dA$ being zero, (a) becomes:

$$M = E . \frac{d\phi}{ds} \int \eta^2 . dA - EI . \frac{d\phi}{ds} \quad \ldots\ldots\ldots (a)$$

With the co-ordinate system as shown in Fig. 2, ϕ is positive on the lower half and negative on the upper half of the column; $d\phi$ is negative and consequently $\frac{d\phi}{ds}$ is also negative all over. Therefore the moment M must be inserted in the equation as: $-W.y$.

Finally (a) becomes:

$$-W y = EI . \frac{d\phi}{ds} \quad \ldots\ldots\ldots (6)$$

By differentiation of (6) and setting $\frac{W}{EI} = \frac{1}{a^2}$, we get:

$$-\frac{dy}{ds} = -\sin\phi = a^2 \frac{d^2\phi}{ds^2}.$$

multiplying by $2d\phi$ and ingration gives:

$$2 \cos\phi = a^2 \left(\frac{d\phi}{ds}\right)^2 + C \ldots\ldots\ldots (7a)$$

In point A fig. 2: $\phi = \phi_0$ and $y = 0$ and according to (6) $\frac{d\phi}{ds} = 0$, which determines C, and (7a) becomes:

$$2 (\cos\phi - \cos\phi_0) = a^2 \left(\frac{d\phi}{ds}\right)^2 \quad \ldots\ldots\ldots (7b)$$

Inserting in (7b) : $\frac{d\phi}{ds} = -\frac{W}{EI} y = -\frac{y}{a^2}$ taken from (6), we get:

$$y^2 = 2a^2 (\cos\phi - \cos\phi_0),$$

or:

$$y = a \sqrt{2} \sqrt{\cos\phi - \cos\phi_0} \ldots\ldots\ldots (7)$$

The maximum deflection is obtained when $\phi = 0$.

$$f = a\sqrt{2}\sqrt{1 - \cos\phi_0} = 2 a \sin \tfrac{1}{2}\phi_0 = 2 \sqrt{\frac{EI}{W}} \sin \tfrac{1}{2}\phi_0 \ldots\ldots (8)$$

Here ϕ_0 is still unknown. It is to be determined so that the length s of the deflected column equals the original length l minus the shortening $\frac{Wl}{EA}$, caused by direct compression W:

$$s = l - \frac{Wl}{EA}.$$

The length of the elastic curve is determined by (7b):

$$ds = -\frac{a}{\sqrt{2}} \frac{d\phi}{\sqrt{\cos\phi - \cos\phi_0}}$$

("minus," because ϕ decreases when s increases).

$$\frac{1}{2} s = -\int_{\phi_0}^{0} \frac{a}{\sqrt{2}} \frac{d\phi}{\sqrt{\cos\phi - \cos\phi_0}} = \frac{a}{\sqrt{2}} \int_0^{\phi_0} \frac{d\phi}{\sqrt{\cos\phi - \cos\phi_0}}$$

This integral is the same elliptical integral that occurs in the treatment of the mathematical pendulum. It is generally solved by a transformation and serial development, whereby is obtained:

$$s = \pi a \left[1 + \left(\frac{1}{2}\right)^2 . \sin^2 \frac{\phi_0}{2} + \left(\frac{1 . 3}{2 . 4}\right)^2 . \sin^4 \frac{\phi_0}{2} + - - -\right]$$

If 4th and higher powers of sin ½ϕ_0 are ignored (this approximation is far closer than previously), we get:

$$\sin \frac{\phi_0}{2} = 2 \sqrt{\frac{s}{\pi . a} - 1}.$$

This value is inserted in (8):

$$f = 4\sqrt{\frac{s}{\pi} a - a^2} = 4 \sqrt{\frac{s}{\pi} \sqrt{\frac{EI}{W}} - \frac{EI}{W}}; \ldots\ldots\ldots (9)$$

Resume.

$W = \frac{\pi^2 EI}{s^2}$ gives $f = 0$ (not indeterminate as in the Euler formula).

When $W < \frac{\pi^2 EI}{s^2}$, f is imaginary.

$W > \frac{\pi^2 EI}{s^2}$ gives definite values of f, but these increase with such dangerous rapidity for small increases of W that $W_{Euler} = \frac{\pi^2 EI}{l^2}$ practically must be considered the ultimate load which cannot be exceeded without imminent danger of failure.

Finally it must be remembered that the ultimate fibre stress must not exceed the elastic limit.

In conclusion a few historical data:

The Euler formula was first given out by Euler in the year 1757. The exact treatment was already (according to Todhunter: A history of elasticity, etc., from Galilei to the present time, 1893) carried through by Lagrange 1770-73. His method has later been simplified in different ways.

The method applied above may also be found in: A. Ostenfeld, Teknisk Elasticitets Laere. Also see: Flamant, Resistance des materiaux, Paris, 1886; and an article of Collignon in Ann. des ponts et chaussees, 1889, I page 98, and Grashof: Theorie der Elasticitat und Festigkeit, Berlin, 1878, and several others.

In a future article the above theoretical results will be further discussed and compared with results of tests. These will finally be used to develop concise formulae for demensioning of practical columns taking into consideration the flexibility and ultimate fibre stress as well as eccentric loading, in homogeneous material, etc.

PRICES OF BRIDGE CONSTRUCTION MATERIALS.

An interesting outline of the present situation in the bridge construction field was given by Mr. M. M. Tokelson, Bridge Engineer of the Wisconsin Highway Commission, at the 6th Annual Road School of the Commission. Portions of Mr. Tolkelson's address follow.

During the 7 years from 1908 to 1915 the steel market was in a comparatively normal condition. There were variations, it is true, and some of them were large, but nothing approaching the high prices which now prevail. Prices at the mill varied from a minimum of about $24 per ton to a maximum of about $40 per ton; stock prices reached a minimum of about $32 and a maximum of about $50 per ton.

Just two years ago, prices were at the lowest. The sharp advance began in the fall of 1915. Where stock prices in August had been $36 per ton, they advanced to $48 in December, to $54 in January and $62 in April. The price held reasonably stable until September, when the price went to $65, to $74 in November, and the latest is $97. All of these figures are for plain unfabricated stock material f. o. b. cars, Chicago. It is practically double what was paid for erected material two years ago. Mill prices are, of course, lower, but delivery is problematical. Ordinarily, nine months delivery is specified, but the mills are so full of orders that they take their own time and deliver to the shop when they please. The buyer can either stand for this or cancel the order.

A very good understanding of present conditions, as compared with average conditions, may be reached by comparing the prices of two bridges, one built by direct contract of the Wisconsin Highway Commission in the years 1915 and 1916, the other contracted in December, 1916. The first was built at Nekoosa, Wood County. The bridge was 875 ft. long, 18 ft. roadway, creosoted wood block floor. The estimated quantity of steel was 366 tons, of concrete 1,276 cu. yd., of creosoted wood block paving 1,656 sq. yd., and there were 46 wooden piles. The contract price was $42,889. As nearly as can be estimated the steel cost $63 per ton, the concrete $10 per cubic yard, the paving $4.00 per square yard, and the piles 50 ct. per linear foot.

The other bridge is to be built in the town of Trenton, Pierce County, and was contracted on December 29th, 1916. The plans call for a bridge 600 ft. long, 20 ft. roadway, creosoted wood block floor. The estimated quantity of steel is 273 tons, of concrete 537 cu. yd., of creosoted wood block paving 1,280 sq. yd., and there are 116 wood piles. The contract price is $43,434. As near as can be estimated, this represents $108 per ton for the steel, $11 per cubic yard for the concrete, and $4.50 per square yard for the paving, and 52 ct. per linear foot for the piles. The steel has apparently advanced 71½ per cent, the concrete 10 per cent, the paving 12½ per cent, and the piling 4 per cent.

The Nekoosa job, however, was not built at the lowest rate. In the fall of 1914 the Commission designed three large jobs for one of the Northern counties. As nearly as can be determined, the steel in these jobs went for $50 per ton erected, and the concrete for about $7 per cubic yard. This would make steel prices at the first of the year more than 100 per cent higher than they were two years ago.

The items entering into the cost of concrete are cement, sand, gravel, forms, and labor. Cement is up decidedly. Probably this item alone will make bridge concrete cost $1 a cubic yard more than the cost two years ago. The cost of sand and gravel depend largely on labor and will advance as labor advances; freights are the same as a year ago. The cost of forms is also up some. But taking everything into account, it is not thought that concrete will cost more than 35 per cent in excess of the price of two years ago. Studies made by the Commission indicate that wherever it is feasible to use a succession of moderately short spans, say from anything up to 60 ft., under present conditions a reinforced concrete bridge can be built at a slightly less cost than a steel bridge.

The Commission recently designed a bridge of 180 ft. length, 20 ft. roadway. After some preliminary estimates, it was decided to use four reinforced concrete spans of 45 ft. length. On this basis, the estimated quantity of steel in the structure is 45,900 lb., of concrete 571 cu. yd. If a steel superstructure were substituted there would be 99,300 lb. of steel and 418 cu. yd. of concrete. Estimating steel at 6 ct. per pound and concrete at $12 per cubic yard, the cost of the reinforced concrete structure will be $9,606, and the cost of the steel spans $10,874.

LIGHT REFLECTING VALUES OF PAINTS.

The coefficient of reflection of several colors as compared to a block of magnesium carbonate, which is white, was determined by H. A. Gardner and his results are published in the Journal of the Franklin Institute for last January. The values determined for the reflecting power of various pigments used in coloring walls are as follows:

	Coefficient of reflection. Per cent.		Coefficient of reflection. Per cent.
White standard (mag. carbonate)	88	Light terra-cotta	41
Light cream	66	Medium terra-cotta	39
Light pink	60	Light greenish blue	36
Light yellow	58	Medium blue	32
Light blue	55	Warm green	19
Light greenish yellow	54	Medium green	14
Light buff	52	Red	12
Light green	42	Blue, dark	12
		Green	11

The citizens of Kansas City, Mo., will vote March 6 on the adoption of a city manager charter. The plan provides for an administrative board of 10 members and mayor, elected at large, who would fix the general policy of the city and appoint the city manager.

METHOD FOR FINISHING CONCRETE SURFACES WITH CARBORUNDUM BRICK.

Excellent results have been obtained in the Green Bay Division of the Wisconsin Highway Commission in improving the concrete bridge surfaces by rubbing with carborundum brick. The methods employed on this work are described as follows by Mr. W. M. Conway, division engineer, in a paper presented at the recent Road School at Madison, Wis.:

First, remove the forms as soon as practicable after the concrete has been poured, and wet the concrete surface with water; for a railing, this will mean anywhere from 24 to 36 hours. Then with a sharp tool remove the lips and edgings left where form boards met.

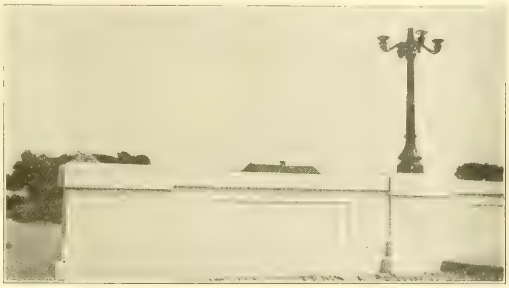


Fig. 1—Railing of Kiel, Wis., Bridge, Showing Effect of Rubbing with Carborundum Brick.

Second, fill all holes with a 1:2 mortar at once. Then float all surfaces, where edges have been removed and where holes have been filled, to an even, uniform surface.

Third, allow the concrete to dry for a week or ten days after following the above procedure. The length of time required for drying and curing before rubbing with a carborundum brick depends entirely upon the weather, the length of time the concrete requires to harden, and to a certain extent upon the aggregate.

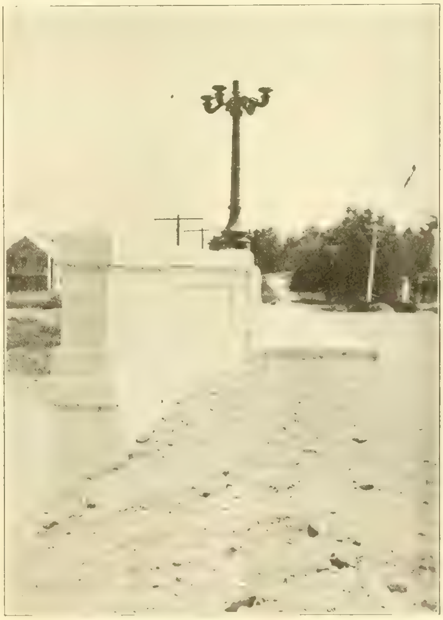


Fig. 2—End View of Railing of Kiel Bridge.

When the concrete has dried sufficiently, the next step is to treat the surface with a cement wash. To make the wash add enough cement to a pail partly filled with water to make the mixture of a creamy consistency. Apply this creamy mixture to the concrete surface with a brush, being careful not to apply too much to any one place, and at the same time enough to fill all the pores. No more surface should be treated in this manner than can be rubbed the following day.

After the cement wash has set 24 hours it should be rubbed off with a carborundum brick by applying water ahead of the brick with a brush, and working the brick in a circular manner. No attempt need be made to wash off the material that is ground off by the brick. This should be left in place and the curlycues straightened out with a dry or only slightly damp brush.

Care should be taken to rub off only the cement wash and no more, for if additional material is rubbed off the aggregate will be exposed. The purpose of the wash is to fill all voids and air holes that appear upon the surface when the forms are removed. The rubbing will not affect small holes that have been filled, but on the other hand will bring the whole surface down to an even, smooth finish of uniform color; something that cannot be obtained in any other way.

To facilitate the rubbing it is important that the concrete be well tamped at the time it is placed in the forms. It is equally important that the form lumber be in good shape, free from knot holes, slivers and splinters, for no amount of rubbing can remove these blemishes or marks.

Concrete which is too wet or sloppy should not be poured into the forms. If a soupy concrete is used, when the forms are removed the concrete has a sandy texture, and is hard to smooth up. On the other hand, it should be reasonably wet and should be tamped into place rather than run into place with an excessive amount of water.

In railings and ballustrades it is quite important to use an excessive amount of rather fine sand and cement and not to much coarse stone. By doing this a much smoother railing will result.

NOMENCLATURE OF CONCRETE DESIGN AND CONSTRUCTION.

At the recent meeting of the American Concrete Institute, the committee on nomenclature, of which Prof. A. B. McDaniel of Union University is chairman, submitted a preliminary list of words and definitions. This list was not intended to be complete nor exhaustive. It is stated that most of the words were not to be found in any English dictionary. The list of words and definitions submitted for the consideration of the Institute follow:

Ambursen Dam—A dam constructed of reinforced concrete consisting of a sloping deck supported by buttresses so arranged that the pressure of the water on the sloping deck is transmitted by the buttresses to the footing causing the water to add to the stability of the structure.

Belt Course—A continuous horizontal member of a building projecting slightly from the elevation and usually moulded in order to produce an architectural effect. (This definition is quite important as on it hangs the validity of one of Ransome's patent claims and when the American-Button suit was argued in court no definition was found that clearly described it.)

Bituminous Shield—A membrane or sheet-like structure composed of alternate layers of tar paper or asphalted felt and coal-tar pitch or asphalt placed in a concrete wall or floor to prevent the passage of moisture.

Book tile—A terra cotta tile occupying a space about 2 in. thick and usually formed by splitting a 4-in. hollow tile in half. (Also known as split furring.)

Buggy (Concrete)—A hand cart for the transporting of wet concrete.

Carborundum Rubbing—Labor applied to smoothen the surface of concrete work by rubbing with a carborundum stone and a little cement and water.

Cement Gun—An apparatus used for the application under pressure of a mixture of cement, sand and water.

Cement Wash—An application of cement and water with a brush to the surface of concrete to give the surface a uniform color and appearance.

Centering—(See "Forms").

Chute (Concrete)—A concrete chute is an arrangement of metal troughs or tubes through which wet concrete is transferred from a mixer or hoisting tower to the forms.

Column Head—Projecting concrete at the top of the column usually used in connection with flat slab or mushroom floors.

Composition Flooring—A floor surface formed of various chemicals and a filler mixed with water and laid in a plastic condition, trowelled smooth and then allowed to set hard.

Continuous Action—A term applied to two or more concrete beams poured at the same time so as to be monolithic and which have the power of transmitting to each other the internal forces caused by loads on each other.

Curtain Wall—An external wall of concrete, brick, tile, or other material, which rests upon the concrete floor construction and does not itself form a supporting member of the building, its load being entirely carried by the floor construction onto the columns.

Deformed Bar—A steel reinforcement bar which has been passed through special rolls in order to produce projections in the same, thus securing a mechanical bond between the concrete and the bar.

Deadman—A heavy timber embedded in the ground to serve as an anchorage.

Drop Panel—The projecting section of a flat-slab floor over the column head and designed to take care of the shear at this point.

Expanded Metal—A form of concrete reinforcement made of sheet steel which has been slit and pulled out to form a diamond mesh.

False Work—See "Forms."

Fillet, Angle—A small triangular fillet of wood which is placed in the angle of rectangular column or beam forms in order to produce a chamfered edge.

Flat Slab—A term applied to reinforced concrete floors which are so constructed that no beams appear beneath their lower surfaces.

Formwork—A temporary construction usually of woodwork to receive the wet concrete which is poured into the same and allowed to set. After the concrete is set, these forms are removed. (Also known as false work or centering.) The following definitions apply to wooden forms: Beam Bottom—A series of boards fastened together with cleats on one side and used for forming the bottom of beams. Beam Side—A series of boards fastened together with cleats on one side and used for forming the sides of beams. Brace—A timber placed diagonally between the posts in floor form-work to stiffen the supports. Cleats—Strips of wood used to hold together a series of boards forming a beam side or bottom or a column side. Column Clamp—An arrangement of wood, steel or iron members designed to hold column forms in position to resist the pressure of wet concrete against their sides. Column Side—A series of boards fastened together by cleats or yokes and used for forming the sides of columns. Column Yoke—Wood or iron members designed to resist the bursting tendency of wood column forms when full of wet concrete. Girt—A longitudinal timber laid crosswise under the joists and used as a girder to support the floor formwork. Jacks—A vertical support for the form-work of beams and provided with a cross-piece at the top and two short diagonal braces. Joists—A longitudinal timber, placed under the panels of floor form-work. Ledger—A horizontal timber used to brace the posts in floor form-work. Panel—A group of boards fastened together with cleats on one side and used for forming the lower surface of floor slabs and for wall surfaces. Posts—A vertical timber used to support the form-work of floors. Re-Stud—A temporary vertical timber used to support the weight of a floor until thoroughly set. Ribband—A horizontal timber used to hold the bottoms of beam sides in place.

Gin Pole—A pole or mast to which a block and tackle are attached for the purpose of hoisting materials.

Granolithic—A floor surface formed by a mixture of cement and very fine crushed stone and sometimes an addition of sand, it being trowelled smooth while wet and allowed to harden.

Grout (noun)—A mixture of cement and sand and water sufficiently liquid to flow like soup.

Grout (verb)—To grout is to fill a cavity or joint with a mixture of cement and sand.

Gunite—A trade term applied to the operation of covering surfaces with cement, sand and water by means of spraying it on with compressed air through a nozzle (See Cement Gun.)

Guy Derrick—A derrick the mast of which is secured by guy ropes to "dead men" or to other anchorages.

Handle Nut—A nut with a handle forged on the same and used in form-work and other temporary construction work to obviate the necessity of using wrenches.

Hickey—An iron tool about 3 ft. long with hooked ends used while the floors are being concreted to lift the reinforcement bars in the wet concrete so that the concrete can flow around and under them when pouring a floor.

Hickey Bar—A steel bar wired to the main reinforcement of a floor to hold the bars in the correct position and at the right elevation.

Hollow Dam—A dam of reinforced concrete consisting of a sloping deck and sloping front resting on buttresses and on a footing. (See also Ambursen Dam.)

Hooping—A steel or wire band placed at regular intervals around the column steel to hold same in position while the concrete is being poured and often designed to allow higher stresses in the concrete of the column and to resist the hoop tension.

Spiral Hooping—Spiral hooping consisting of iron bars bent to a spiral form for wrapping the vertical reinforcement in a column and designed to allow higher stresses in the concrete of the column and to resist the bursting tendency in a heavily loaded column.

Inserts—A cast iron or malleable iron socket either slotted or tapped to receive bolts for attaching shaftings, sprinkler pipes or other articles to a concrete surface. Inserts are usually placed upon the forms before the concrete is poured and remain embedded in the concrete after the forms are stripped.

Inspector—A person designated by the owner, the architect or by the city to inspect the building operations to insure that the work is being done according to the specifications and the city regulations.

Laitance—A scum of finely divided inert particles which rises to the surface of wet concrete before setting.

Mud Sills—Part of the formwork of a floor consisting of members of timber laid upon the surface of the rough ground and wedged up in order to provide a level bearing for the posts of the floor formwork.

Mushroom Floor—(See "flat slab.")

Mushroom Head—The enlarged head or capital of a concrete column which is used to support the flat slab or mushroom floor of a reinforced concrete structure.

Negative Steel—Steel reinforcement inserted in the reinforced concrete structure to take-up negative bending moments.

Precast Concrete—Concrete which is cast into forms and then hoisted and set in place. (See also Unit Construction.)

Plaster or Plastering—A mixture of cement and sand, or lime and sand usually with some hair added applied in successive coats to vertical and horizontal surfaces.

Punching Shear—The tendency of a concrete column or other vertical member to shear or punch through the footing upon which it rests.

Radial Bar—A steel bar placed in the column of a mushroom floor and bent down and set so that the ends radiate from the center of the column. These bars support the main floor steel of the floor and act as hickey bars.

Routing Clerk—The man who directs the movements of all the materials of which a structure is to be constructed.

Screed—A wooden strip laid along a wall at intervals to serve as a gage for a mortar or a plaster surface.

Sleeper—A wooden strip placed at intervals along a concrete slab to serve as a nailing strip for the wooden flooring.

Sleeves—A tube or box of wood or metal placed on the forms of a floor in order to core out a hole for the passage of a pipe or wire.

Spacer—A metal bar placed in a concrete floor, wall or column and used to tie the reinforcement together and hold it in its proper position.

Spline—A tongue of wood placed in two grooves of adjoining plank in order to make a tight joint between them.

Splined Plank—Plank grooved on both edges in order to receive tongues of wood as described above. (See "Spline.")

Stirrups—A piece of steel reinforcement placed in a beam in order to resist shearing stresses in the concrete.

Tooling—The finishing of concrete surfaces with a toothed or pointed hammer producing a surface which will show the lines of the tool.

Traveller—A temporary structure, usually of steel but sometimes of wood, which is employed to raise into position the structural members of a bridge or other structure and which in itself is so constructed that it can move backward and forward in accordance with the progress of the bridge.

Tremie—A collapsible, sectional, cylindrical spout used in placing concrete under water.

Twisted Bar—A steel bar which has been twisted either before or after cooling in order to raise its elastic limit. Bars twisted before cooling are known as hot twisted and those which are twisted after cooling are known as cold twisted.

Unit Construction—A system of reinforced concrete construction in which all the members are cast independently and later erected into place by derricks and grouted into position.

Wall Beams—A concrete beam at the edge of the floor slab which shows on the outside face of the building.

Wall Bolts—An iron bolt threaded at both ends used in formwork to bolt the forms of the two sides of a wall together, and also used in column forms in a similar manner.

Weep Holes—Holes for the drainage of floors of buildings and bridges and located in the walls or floors.

Well (Elevator)—A compartment or chamber in a building running vertically the full height of same to receive a passenger or freight elevator.

Wing Nut—A nut with two opposite projecting wings so arranged as to obviate the use of wrenches and used in formwork and other temporary construction work.

Wire Fabric—A form of concrete reinforcement composed of parallel longitudinal wires tied together at intervals by transverse wires.

PROTECTING BRIDGES FROM LOCOMOTIVE GASES.

The Highway Engineers Department of Baltimore, Md., has adopted the practice of covering the principal members of the floor system of certain bridges with a coating of reinforced concrete as a means for protecting them from the corrosive action of gases emanating from locomotives.

The plan as carried out during the past year provides for a covering of 1½ in. of reinforced concrete to be applied to the longitudinal and transverse floor beams and other members. The iron work is first thoroughly cleaned, then, after being wrapped with reinforcing material, forms are built around members wherever practical, and concrete poured into them. On the larger members the concrete is plastered on by skilled workmen.

METHODS AND COST OF ERECTING THE ST. PAUL, NEB., STATE AID BRIDGE.

Contributed by Geo. K. Leonard.

The contract for this bridge was let in September, 1915. It is located one mile from the town of St. Paul, Neb., and extends over the Middle Loup River. The right of way adjoins that of the Union Pacific R. R. and the same length of spans was used so that the piers in the two bridges would fall in the same line. The entire bed of the river at this point is composed of fine sand with some gravel too deep to excavate economically for concrete. During the summer the river is practically dry with the exception of one channel under Span No. 5. The general layout of the structure is shown in Fig. 1. The material quantities also are shown in this cut.

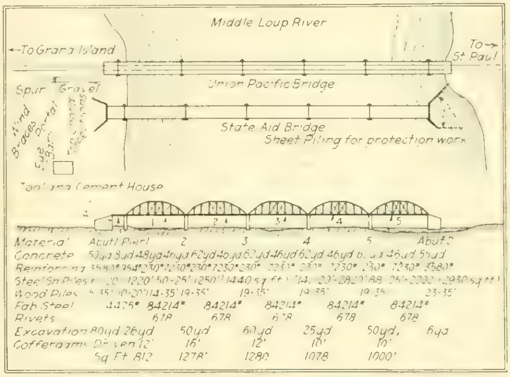

Middle Loup River
←To Grand Island
To→ St Paul
Union Pacific Bridge
Spur
Gravel
Wind Braces
Portal
State Aid Bridge
Sheet Piling for protection work
Tools and Cement House
1
2
3
4
5
Material Abut1 Pier1 2 3 4 5 Abut2
Concrete 50yd 8yd 48yd 46yd 62yd 46yd 62yd 46yd 62yd 46yd 46yd 5yd
Reinforcing 3580# 254# 230# 7230# 230# 7230# 230# 7230# 230# 7230# 230# 7230# 3580#
Steel Sh Piles 1220' 50-25' 1250' 1440 sq ft 14, 20'-2820' 88 25'-2200 2930 sq ft
Wood Piles 35' 20' 14-35' 19-35' 19-35' 19-35' 19-35' 23-35'
Fab Steel 4475# 84214# 84214# 84214# 84214# 84214#
Rivets 678 678 678 678 678
Excavation 80yd 26yd 50yd 60yd 25yd 50yd 6yd
Cofferdams Driven 12' 16' 12' 10' 10'
Sq Ft 812 1278' 1280 1078 1000'

Fig. 1—General Layout of St. Paul, Neb., State Aid Bridge and Material Quantities Involved.

The superstructure is composed of five 8-panel 145-ft. pin-connected curved chord trusses and one 20-ft. I-beam span, all with a 16-ft. roadway, carrying a 6-in. concrete floor. It was designed to carry a live load of 75 lb. per square foot, or a 15-ton traction engine.

The substructure includes five mass concrete piers and two reinforced concrete abutments resting on 35-ft. cypress piles. A row of 7-in. Lackawanna steel sheet piling 20 ft. long is driven under the whole length of each abutment and adjoining these on Abutment No. 2 additional piling are driven for protecting the approach. The concrete extends to a depth of 3 ft. below the low water level and the piles are embedded in the footings 2 ft.

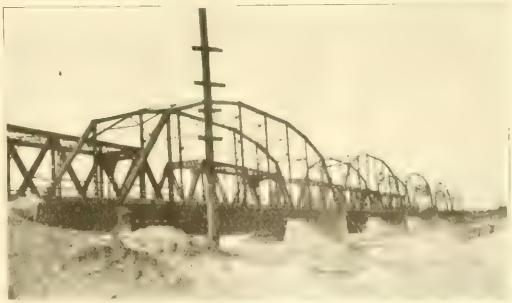


Fig. 2—Completed Bridge.

At the start of the work the contractor made arrangements with the Union Pacific R. R. for the construction of a spur to the end of the highway bridge. All material with the exception of the form lumber, which was hauled from St. Paul, was delivered to the bridge site on this spur. The cost of the spur was charged to the various materials according to their tonnage, as follows:

Material.	Amount.	Tonnage.	Amount charged.
Steel Sheet piles	7,196 lin. ft.	17.00	$ 15.72
Wood piles	4,330 lin. ft.	64.95	21.25
Falsework piles	4,315 lin. ft.	64.73	21.20

Cement	977 bbls.	195.40	64.00
Gravel		1,096.00	358.60
Reinforcing steel		22.71	7.43
Fabricated steel		212.77	69.60
Coal		166.20	54.40
Plant		25.00	8.20
Total tonnage		1,894.76	
Total cost spur			$620.00

Total cost spur ton of material 32.7 ct.

These amounts which are charged to the material from the spur will hereafter be charged to hauling, since the spur did away with the hauling costs.

Labor Organization.

The labor organization was as follows:

	Per hour. Cents.
Pile driving:	
1 foreman	40
1 engineer	40
1 niggerhead man	35
1 fireman	30
1 jet man	30
3 laborers	30
Concrete:	
1 mixer man	35
5 cart pushers	30
2 tampers	35
1 cement man	30
4 gravel wheelers	25
Steel erection:	
1 foreman	40
1 engineer	40
1 niggerhead man	35
1 fireman	30
2 laborers	40
2 laborers	35
4 laborers	30
Riveting (two gangs):	
1 foreman	42½
1 compressor man	35
1 fireman	30
2 rivet heaters	42½
1 gun man	42½
1 gun man	40
2 buckers	35
2 rivet catchers	35
2 fitting-up men	35
1 supply man	25
General foreman	45
Night watchman	20
Water boy	15

Plant.

Piles were driven and a platform built from the spur to the end of the bridge. On this the plant was erected and part of the material unloaded. For the pile driving a traveler carrying a stiff-leg derrick and a steam hoisting engine, operating a 1,600-lb. hammer in swinging leads, was used. A small jet pump assisted greatly in all the pile driving.

The cofferdam at Pier No. 1 was first driven, using the sheet piling, which were afterward driven under the abutments. The excavation was done with an orange-peel after which the wood piles were driven. Next the falsework of Span No. 1 was driven, the floor beams being placed on each successive bent and enough joists to carry the traveler bolted to the beams. The work progressed in like manner across the bridge.

Concreting followed the pile driving and after the footings were poured the traveler returned and pulled the cofferdam.

In Abutment No. 2 the sheet piling served for both cofferdam, and forms around the face and wood forms had to be sunk around the rear. Abutment No. 1 was finished last.

At the start a ¼-yd. mixer was used, being run by a gas engine. Later a steam engine and boiler were used. In mixing for Piers Nos. 1 and 2 the mixer was set over the forms, but it was then moved to the end of the bridge and the rest of the concrete was mixed there and hauled to the forms in Koppel cars.

The cost of the plant and its distribution is as follows:

Making working platform	$ 85.00
Making tool and cement house	30.00
Unloading and erecting derrick	88.00
Erecting and moving concrete plant	164.90
Repairs on derrick	194.89
Wrecking and loading out plant	178.75
Hauling	8.20
Total	$749.74

This was charged to the various branches of the work according to the time spent on same. If the unit costs are desired without the plant included it is very easily found.

Following is the distribution of the plant cost to the various branches:

Kind of work.		Repairs.	Total charged.
Driving falsework	$ 53.52	$ 27.35	$ 80.87
Driving sheet piling	12.05	....	12.05
Driving wood piling	165.56	80.47	246.03
Driving cofferdam piling	74.00	78.32	152.32
Steel erection	84.82	8.75	93.57
Concreting	164.90	....	164.90
Totaling	$554.85	$194.89	$749.74

Coal.	Cost per ton.	Total cost.
166.2 tons	$6.43	$1,068.66
Unloading	.185	30.74
Hauling	3.27	54.40
Total	$6.942	$1,153.80

Cost Data.

SUPERSTRUCTURE.

Falsework:	
Labor driving	$ 711.55
Labor removing	112.15
Coal (18 tons)	125.00
Plant	80.87
Total	$1,029.57
Cost per span	205.91
Cost per lin. ft. bridge	1.42
Cost per ton steel	4.90

These units include laying floor beams and enough joists to carry the traveler.

Erecting (excluding approach):	
Labor erecting	$ 936.85
Coal (28 tons)	194.20
Plant	93.57
Total	$1,224.62
Cost per span	244.92
Cost per lin. ft. bridge	1.69
Cost per ton steel	5.83
Labor erecting approach	5.40
Cost per ton	2.61
Riveting:	
Labor riveting	$ 936.85
Setting compressor	88.88
Coal (16 tons)	111.00
Total	$1,136.73
Cost per span	227.34
Cost per ton steel	5.41
Cost per rivet	.336
Painting (one coat):	
Labor painting	$233.96
Cost per span	46.79
Cost per ton steel	1.12
Falsework piles:	
1,875 lin. ft. at 15 ct	$281.25
140 lin. ft. at 15½ ct	21.70
2,300 lin. ft. at 13½ ct	310.50
Totaling 4,315 lin. ft.	$613.45
Hauling	21.20
Total	$634.65
Cost per span	126.94
Cost per lin. ft. bridge	.88
Cost per ton steel	2.98

Fabricated steel:	Cost per ton.		Total cost.	
Hauling	$ 0.327		$ 69.60	
Unloading	.623		131.97	
Total		$ 0.950		$ 201.57
161 ton trusses (est.)	$55.00		$8,855.00	
49.7 ton joist (est.)	39.00		1,938.30	
210.7 tons ft. (est.)	12.00		2,528.40	
Average		59.50		13,421.70
Total		$60.45		$13,623.27

Total per span	2,724.66
2.07 tons approach at $51.00	105.57
Paint (one coat):	
110 gal. at $1.00	$110.00
Cost per span	22.00
Cost per ton steel	.518
Paint per ton	.518

SUMMARY SUPERSTRUCTURE.

	Labor.		Material.		Total.	
	Span.	Ton.	Span.	Ton.	Span.	Ton.
Falsework	$205.91	$ 4.90	$ 126.94	$ 2.98	$ 332.85	$ 7.88
Steel	244.92	5.83	2,724.66	60.45	2,969.58	66.28
Riveting	227.34	5.41	....	......	227.34	5.41
Painting	46.79	1.12	22.00	.52	68.79	1.64
Total	$724.96	$17.26	$2,873.60	$63.95	$3,598.56	$81.21

Total cost of five spans	$17,992.80
Total cost of approach	110.91
Total cost of superstructure	18,103.71

SUBSTRUCTURE.

Wood piles (top of piles driven 12 in. below low water):

	Per lin. ft.	Per pile.	Total.
Labor pointing and carrying to position	$0.0213	$ 1.059	$ 135.61
Labor driving	.1159	3.925	502.31
Coal (56 tons)	.0897	3.035	388.50
Plant	.0569	1.908	246.03
Hauling	.0049	.166	21.25
Total	$0.2987	$10.093	$1,293.70
4,330 lin. ft. piling	.155	5.42	671.15
Total cost piling	$0.4537	$15.513	$1,964.85

Steel sheet piles (top of piles driven to water line):

	Per sq. ft.	Per lin. ft.	Per mile.	Total.
Labor carrying to position	$0.01762	$0.01014	$0.224	$ 75.95
Labor driving	.0835	.048	1.059	359.55
Coal (4 tons)	.00644	.00371	.082	27.76
Plant	.0028	.00161	.035	12.05
Hauling	.00356	.00204	.045	15.32
Total	$0.11392	$0.06550	$1.445	$ 490.63
Piling	.4618	.27	5.93	2,018.15
Total cost piling	$0.57572	$0.33550	$7.375	$2,508.78

Lumber:	
31.5 M ft. B. M.	$861.55
Cost per yard concrete	1.35
Forms:	
Abutments—	
Labor placing	$333.99
Labor removing	36.90
Total	$370.89
Cost per yard concrete	3.53
Piers (including placing small amount of steel)—	
Labor placing	$279.74
Labor removing	55.00
Total	$334.74
Cost per yard concrete	1.13
Floor—	
Labor placing	$290.70
Labor removing	113.20
Total	$403.90
Cost per yard concrete	1.70

Cement:	Per bbl.	Total cost.
977 barrels	$1.80	$1,758.60

Unloading	.062	60.[illegible]
Hauling	.065	64.90
Total	$1.927	$1,882.97
Barrels per yard (foundation)		1.45
Cost per yard concrete		$2.80
Barrels per yard (floor)		1.65
Cost per yard concrete		$3.18

Gravel:

	Per ton.	Total cost.
1,096 tons	$1.21	$1,327.02
Unloading	.157	171.53
Hauling	.327	358.60
Total	$1.694	$1,857.15
Tons per yard concrete		1.715
Cost per yard concrete		$2.90

Concrete

Plant	$164.90
Cost per yard concrete	.26
Foundations—	
Labor placing	$715.42
Coal (10 tons)	69.40
Gasoline (250 gal.)	53.13
Total	$837.95
Cost per yard concrete	2.09
Floor—	
Labor placing	$484.80
Coal (9.7 tons)	67.30
Total	$552.10
Cost per yard concrete	2.32

Cofferdams (5 piers only):

Preparing site	$ 32.40
Driving piles	241.11
Pulling piles	575.22
Excavating	160.32
Plant	152.32
Coal (24.5 tons)	170.03
Total	$1,331.40
Cost per yard concrete	4.50

SUMMARY CONCRETE.

	Abutments.		Piers.		Floor.	
	Total.	Per yd.	Total.	Per yd.	Total.	Per yd.
Lumber	$ 141.75	$ 1.35	$ 399.10	$ 1.35	$ 321.10	$ 1.35
Forms	370.89	3.53	334.74	1.13	403.90	1.70
Cement	294.00	2.80	829.80	2.80	759.17	3.18
Gravel	304.50	2.90	858.40	2.90	694.25	2.90
Mixing	246.55	2.35	694.90	2.35	613.50	2.58
Cofferdams	....	......	1,331.40	4.50	....	....
Total	$1,357.29	$12.93	$4,448.34	$15.03	$2,791.92	$11.71

Total charged to concrete $8,597.55

REINFORCING.	Per ton.	Total cost.
15,410 lb.	$60.00	$1,362.30
Unloading	.382	8.[illegible]7
Hauling	.327	7.13
Total	$60.709	$1,378.49
Placing in abutments		19.28
Cost per ton		8.55
Placing in floor		90.60
Cost per ton		6.74

SUMMARY SUBSTRUCTURE

Wood piles	$ 1,964.85
Steel sheet piles	2,508.78
Concrete	8,597.55
Reinforcing	1,488.28
Total	$14,559.46

TOTAL COST OF BRIDGE.

Superstructure	$18,103.71
Substructure	14,559.46
Miscellaneous material	535.00
General foreman	810.00
Night watchman	260.00
Water boy	47.75
Total	$34,315.92

ENGINEERING CO-OPERATION.

At the second conference on Engineering Co-operation held last April in Chicago, a series of resolutions were adopted covering the points that existing agencies, through lack of proper correlation, appeared inadequate for the solution of many problems vitally affecting the practice of engineering and that it was the sense of the conference that certain desirable ends may usually be attained through closer association and co-operation among engineering societies. A sub-committee accordingly was established with instructions to prepare a plan for forwarding co-operation among engineering societies upon matters of general interest to the engineering profession, such plan to be presented for formal consideration at a third conference on engineering co-operation to be called by the sub-committee. The sub-committe has now completed it work and will present the following report at the third annual conference to be held March 29-30 at the rooms of the Western Society of Engineers, Chicago, Ill.:

1. National Societies.—As a preliminary to all efforts toward co-operation among existing engineering organizations there should be the expressed intent to assist in strengthening and unifying the work of the national engineering societies in the advancement of engineering knowledge and practice and the maintenance of high professional standards.

2. Local Organizations.—The invigorating of local societies is fundamental because of the fact that, while the great national societies are important in setting standards and in considering broad problems, yet local affairs make up at least nine-tenths of the vital problems of the engineer's life. In each locality where there may be a dozen or more engineers so situated as to be able to meet occasionally there should be formed, if not already existing, an engineering association embracing all professional engineers and others interested in engineering to discuss and act upon these vital problems.

3. Home Rule.—Each local engineering society should be autonomous or self-governed, wholly free in its activities from any dictation or control by other association or connections, fully adapted to local needs and conditions, and exemplifying in its activities the principle of complete home rule.

4. Welfare of Members.—Each such local or self-governing unit in its organizations and activities should give full recognition to the fact that the majority of the membership necessarily consists of men not yet enjoying complete or independent professional status, but who in large part have had a college or technical training and who in time may become professional engineers in the full sense of the word. Because of this diverse character of members, the activities of the local society, while maintaining high professional standards, should be so planned as to meet the needs of the young men as well as the older and be directed toward the welfare of all classes of its members, and through them of the public.

5. Ethics.—Each local engineering society should adopt and frequently make application of a code of ethics prepared in accord with the standards established by the national organizations or approved by other professional bodies. It is recognized that, while it is impossible to prevent all violation of such a code, yet eternal vigilance is the price of maintenance of high standards. The enforcement of such a code is essential to the well-being of the community at large as well as for the protection of professional men from the improper competition of unskilled or unscrupulous men, tending to reduce the opportunity for effective service to individuals and to the public.

6. Employment.—For the benefit of the great body of members, those who have not yet attained a standing which enables them to enjoy full professional status, there is needed the development of a scientifically planned and well-conducted system of employment to be operated in co-operation by all engineering associations.

7. Publicity.—Each independent association should maintain a local system of diffusing information on engineering subjects such as may be embraced in the term publicity or of proper advertising of the profession as a whole.

8. Civic Affairs.—Each local society should devote time and thought to local civic, state and national affairs which influence engineering progress and should take an active part in considering proposed new laws.

9. Intermediate Societies.—With complete covering of the ground by vigorous local city and state associations, it is evident that there is no room for an intermediate engineering society such as the Engineering Association of the South, which has recently disbanded with the expectation that strong organizations will succeed it in each of the cities where it has been represented by local sections. Such autonomous societies better fill the need of bringing engineers together in personal contact, arousing the spirit of fellowship and facilitating prompt action.

10. The Public Engineer.—Each local society should give especial attention to the needs of those members who are in public employment and should recognize the high ideals and performance of the public engineer, seeing to it that he is furnished sympathetic support in his efforts in the public service.

11. Conferences.—An occasional conference of representatives from each engineering organization should be held at least annually, at which all matters such as those above noted and others of general interest should be discussed. The expense of one delegate to such conference should be provided by each society.

12. Field Secretary.—Provision should be made for maintaining a traveling secretary of the committee on co-operation who can visit each local body, give personal advice and assistance in ways which may aid in securing the highest efficiency and economy in administration and who can address the membership on larger matters of concern to all engineers.

13. Local Representative.—In each society efforts should be made to develop one or more of the younger members with especial reference to active participation in the co-operative movement, particularly to the diffusion of information on engineering in ways such as will catch and hold the public attention.

14. Printed Matter.—An ample supply of printed matter should be provided for distribution, covering in particular the methods of organization of engineering societies, the maintenance of ethical standards, the ways of securing employment, and of diffusing information, also on other details which are of importance to officers and members of local societies and which will tend to stimulate interest and secure results in the business operations of the society.

Suitable standard blanks and letter forms should be made available for general use in obtaining information concerning employment and for correspondence with persons seeking work, so that the necessary facts may be fully and quickly obtained.

15. Finances.—In order to pay for typewriting, printing, postage and similar expenses, it is necessary to have a small fund at the disposal of the committee on engineering co-operation. At present it is not advisable to ask each of the various engineering organizations to contribute beyond the expense of sending delegates to the conference. In some localities, however, it appears that money may be raised by personal appeal instead of direct assessment, although it is hoped that [illegible] will in time contribute.

The Sub-Committee on Plan consists of Hunter McDonald, Isham Randolph and Morris L. Cooke, with F. H. Newell, Chairman, and C. E. Drayer, Secretary of the Committee on Engineering Co-Operation.

ORNAMENTAL TREATMENT OF CONCRETE ON ELEVATED STATIONS OF NEW YORK CITY RAPID TRANSIT SYSTEM.

Some excellent examples of the ornamental treatment of concrete, including the use of inlaid colored tile, are afforded by structures erected by the Public Service Commission for the First District, New York City. This Commission, which is in charge of the building of the Dual System of Rapid Transit, has adopted the policy of beautifying the elevated stations which it is constructing near parks and at the intersection of important streets forming points of interest in civic centers. These stations for the most part are steel structures, encased with concrete. The method of treatment employed on these structures was described by S. J. Vickers, Designing Architect of the Commission, in a paper presented before the recent convention of the American Concrete Institute, from which the matter that follows is taken.

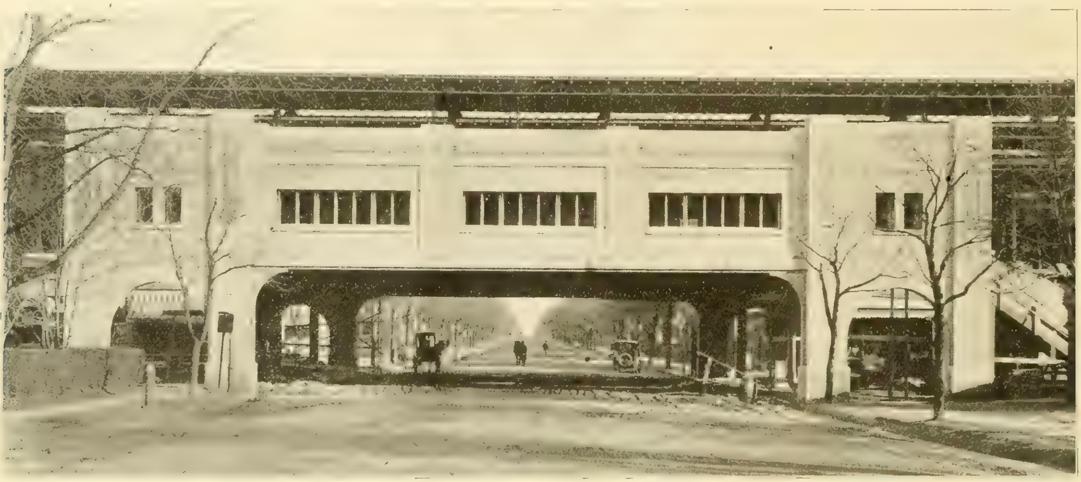


Fig. 1—Elevation of Bay Parkway Station, Showing Treatment of Concrete and Inlaid Tile.

The first specifications called for the concrete to be filled in with special mix on all other or exposed surfaces. This was to be kept from the ordinary concrete by steel shields placed about 2 in. from the outer faces and moved up as the work progressed. This was called for because it was believed it would not be possible to get the color and texture desired in the ordinary concrete.

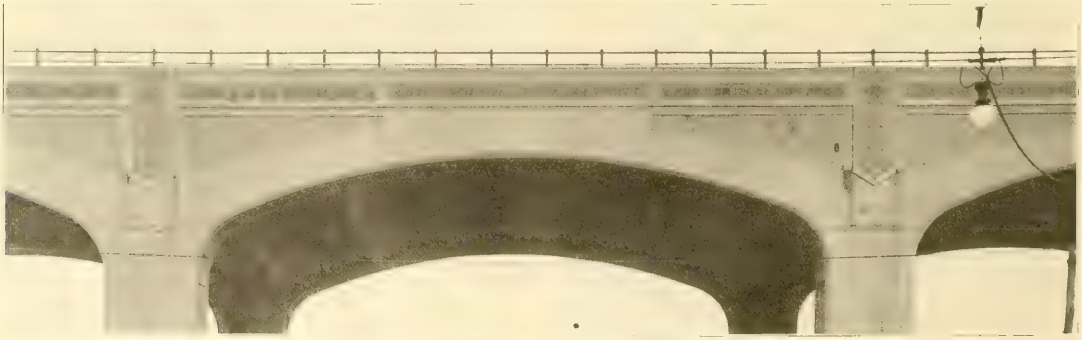


Fig. 2—A 65-ft. Arch of the Queensboro Structure, Showing Inlaid Tile and Treatment of Concrete.

This method was, however, never used, as it was found that by using Long Island gravel, which for the most part is light in color but contains some dark stones which gives a variety, and by properly dressing the surface excellent results could be obtained. The shields and special mix therefore was given up, thereby avoiding considerable structural difficulty.

In pouring the concrete care was taken in getting a uniform mix and working it tightly down against all faces of the forms. Otherwise on their removal there would have been ill formed corners and honeycombed surfaces. There is little hope of filling up these imperfections thereafter, so that they will not show when dressed. Even when extraordinary care is used certain imperfections will appear after the removal of the forms. In certain places it was necessary to cut these imperfections out to a considerable depth and fill with a concrete the same as the original mix, which was 1:2:4.

The inside of the forms was given a coat of cheap lubricating oil prepared especially for this purpose. In certain work it was possible to have the forms removed within a week; on other work such as the reinforced concrete viaduct it was necessary to keep them in place until the concrete was thoroughly set. No dressing was done to the concrete until after it had been set at least a month, as it was desired in the surfacing to chip the gravel to give the surface a bright and sparkling appearance.

On all the stations the dressing was done with pneumatic machines. The four-pointed tool was used on the greater part of the surfaces, but on certain large fields where a rough surface was desired the bull-point or one-pointed tool was used. Bands varying from 2-in. to 4-in. were usually left around all panels and corners which were rubbed smooth, giving a frame or setting to the regular work. On certain work where there were big surfaces, a wider band was left and this was hand-tooled with lines at right angles about ¾-in. apart.

The contractors were required to dress away any unevenness caused by the bulging of the forms, bringing the surfaces to even planes in which all the cement skin was removed and the gravel lying near the surfaces chipped or cracked to give a sparkling affect. By the removal of a considerable portion of the surface most of the board marks disappeared. It is a curious fact, however, that a few board marks will remain although the entire surface is dressed to a plane, this being caused probably by the fine sediment collecting about the joints of the boards.

The most unusual piece of construction with which the Commission is concerned is the reinforced concrete structure for Queens Boulevard in the Borough of Queens, which line extends along the wide boulevard for a distance of 4/5 mile, and is so arranged that trolleys will run underneath the structure, on either side of which is planned a driveway and a strip of park. From the large reinforced columns 65 ft. longitudinal arches and 35 ft. cross arches spring. The form of the vault supported by these arches is in appearance a dome. The entire surface including the domes of this structure was tooled except certain bands and arises and margins of panels. A continuous band of colored tile with a plaque on each column was inserted to add a little color to the gray concrete surface.

About 20,000 sq. ft. of tile was used on this piece of construction. The tile was selected with great care after considerable investigation. It is wet pressed, hand made, semi-vitreous, and glazed, with scores or dovetails on the back to insure a perfect bond with the concrete. The recesses left in the concrete for the insertion of the tile were about 1¾ in. deep and the tile was laid in ½-in. gray joints.

TESTS OF HOOPED CONCRETE COLUMNS WITH CAST IRON CORES.

Tests of hooped concrete columns reinforced with cast iron were completed recently at the Pittsburgh laboratory of the U. S. Bureau of Standards. This work was undertaken at the instance of Mr. L. J. Mensch, M. Am. Soc. C. E., General Contractor, Chicago, Ill., who had the test columns made. In a paper prepared for the recent convention of the American Concrete Institute, Mr. Mensch describes these tests and gives the results obtained. An abstract of Mr. Mensch's paper follows.

Test Columns.

Twenty columns from 6 ft. to 14 ft. long, as shown in Table 1, were made at the end of September and the beginning of October, 1916. The concrete was of 1:1:2 mixture, 12¾ in. outside diameter, 12 in. core diameter of spiral, reinforced vertically with .66 to 1.22 sq. in., and spirally with No. 8 gage wire with 1⅛-in. pitch amounting to .61 per cent of the core area. The cast iron reinforcing consisted in most cases of 6-in. cast iron columns ¾ in. thick, widened at the ends. The length of the test columns were:

2 columns were 6 ft. long.
4 columns were 8 ft. long.
8 columns were 10 ft. long.
2 columns were 12 ft. long.
2 columns were 14 ft. long.
2 plain cast iron columns 8 ft. long.
3 plain cast iron columns 2 ft. long.
With each batch 1 concrete cylinder 6x12" was made.

The cement used was Universal Portland cement. The sand and gravel were the standard materials used in the City of Chicago. Good clean washed torpedo sand, and gravel passing a 1-in. ring containing a mixture of material from ⅜ in. up were used.

The spiral reinforcement was furnished by the American System of Reinforcing, and was standard high carbon No. 8 wire fastened together at two opposite sides with ¼-in. round rods. The ⅜-in. square deformed bars of high carbon steel were wired to the spirals in distances of about 1 ft. No tests were made on the steel reinforcement as the test specimens were lost in shipment.

The columns were made by the American Building Foundry Co., of Chicago, of a mixture of 50 per cent of gray iron and 50 per cent of scrap. Test cubes of 1 in. sides tested by Prof. Duff A. Abrams, of the Lewis Institute, Chicago, showed a stress of 100,000 to 150,000 lb. per square inch, but the actual castings, as typified by a 5-in. column 24 in. long, showed only an ultimate strength of 72,700 lb. per square inch, and an initial modulus of elasticity of 10,000,000 lb. The casting varied only about ⅛ to 3/16 in. in thickness where the core was supported by chaplets, and between these points, varied as much as ½-in. in thickness. The column ends were machined at the foundry. The sections were often 10 per cent less in area than the theoretical section.

The columns were made in a vertical position The reinforcement was in general from ¼ in. to ⅜ in. shorter than the columns. The cast iron columns were considerably displaced at the lower end; as much as 1½ in. in columns 5, 6 and 13. The consistency of the concrete would probably be called mushy. The columns were made between Sept. 26th and Oct. 2nd, during which time the temperature varied from 39° F. to 76° F., with an average of 60°.

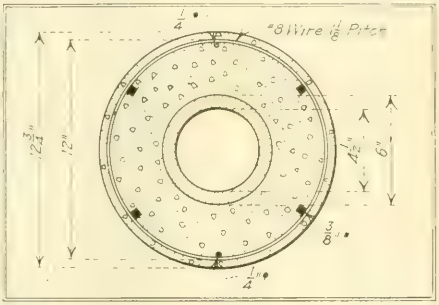


Fig. 1—Section of Columns 1, 2, 3, 11, 12, 17, 18, 19 and 20.

The columns were tested in the 10,000,000-lb. testing machine of the Bureau of Standards Laboratory at Pittsburgh, Pa. In this testing machine the load is applied by means of a hydraulic piston which is actuated by a hydraulic pump. The load is weighed through a system of levers which are connected with the piston of a smaller hydraulic cylinder which communicates with the larger cylinder. The extensometer readings were taken after the pump was stopped and owing to the elasticity of the column, the load slightly dropped off during the five minutes it took to make the fifteen readings. From the few tests to determine the drop, it is believed that it did not amount to more than 1 per cent at the outside. The readings were generally continued until the first crack appeared.

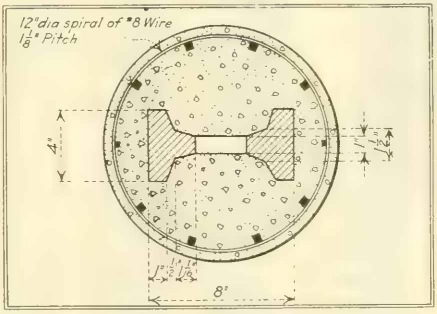


Fig. 2—Section of Columns 15 and 16.

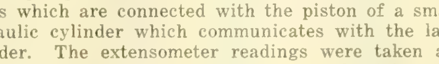
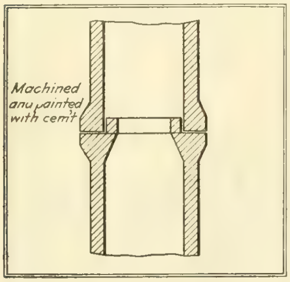


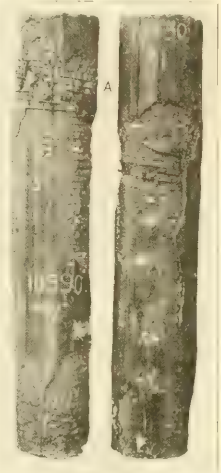
Fig. 3—Elevation of Cast Iron Core of Columns 15 and 16.

Test Data.

The columns were 61 to 66 days old when tested. The test cylinders were tested at about the same time and for hand mixing and a rather low temperature showed high and uniform strength. Table I shows all the general data of tests.

Hooped Concrete Columns Without Cast Iron Reinforcement.—The first crack occurred at an average load of 465,600 lb. or 4,110 lb. per square inch, while the concrete cylinders failed at an average of 3,630 lb. per square inch.





Figs 4 and 5—Left Hand View Shows Detail of Joint 3 ft. From End of Cast Iron Core of Columns 13 and 14. Right Hand View Shows Appearance of Columns 1 and 2 After the Tests. At A, when spiral burst, concrete lost bond and became again sand and gravel.

After the first crack the unit deformation of the column increased faster and the maximum load was evidently reached when the spiral reinforcing was near its ultimate strength. The average maximum load was 540,350 lb. or 4,778 lb. per square inch, which agrees very well with the formula proposed by the National Concrete Institute, according to which:

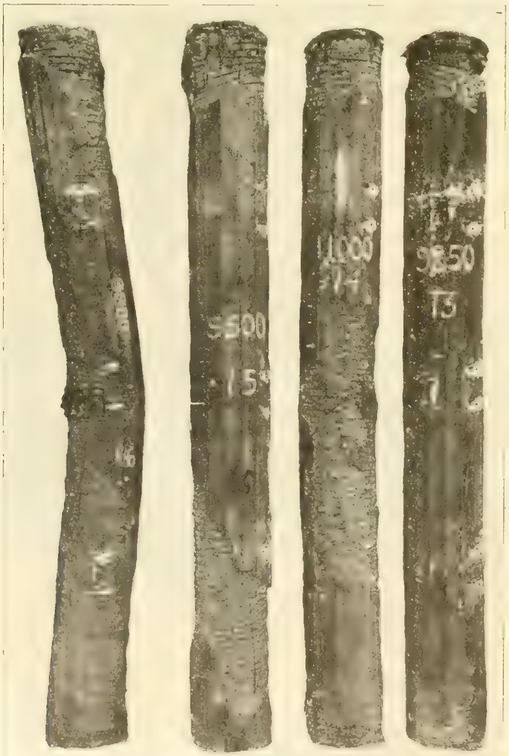


Fig. 6—Appearance of Columns 13, 14, 15 and 16 After Tests.

1 per cent of vertical reinforcement contributes 400 lb. per sq. in.
1 per cent of spiral reinforcement contributes 1,600 lb. per sq. in.
In these cases the ultimate strength per sq. in. = 3,630 + 400 × .58 + 1,600 × .61 = 4,830 lb.

In order to find out how much the cast iron carried in the other columns, the assumption was made that 4,778 lb. was the strength per square inch of concrete within the core and that the remaining load was supported by the cast iron columns.

Columns With Cast Iron Reinforcement.—The 10 columns 8 ft. to 12 ft. long showed very uniform results. Only in column No. 3 the first crack appeared at the low load of 436,000 lb. or about one-half the maximum load; in all other cases the first crack was noticed at the loads of 600,000 to 800,000 lb., or at 6/10 to 8/10 the maximum load. The unit deformation at this time varied from .00125 to .00175, practically the same at which the plain concrete cylinders failed.

At a load of about 800,000 lb. considerable spalling of the outer shell occurred. Sometimes the spalling started at the top or bottom, and then the spalling might start in the center and vice versa, clearly indicating that the cast iron column helped to carry the stresses over the weak spots in the concrete.

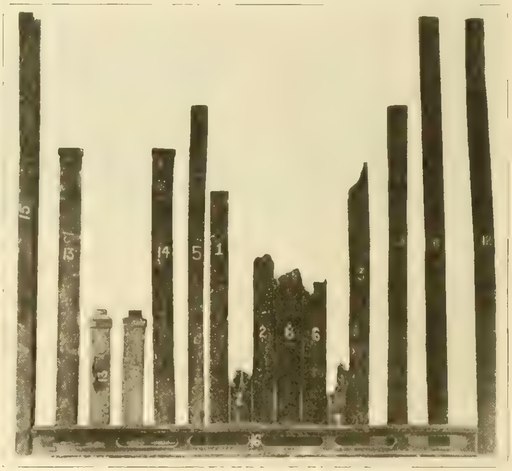


Fig. 7—Appearance of Cast Iron Cores After Tests. Core 16 Was Broken After Removal From Column.

Near the ultimate load, sometimes one or two spirals bursted, but still the cast iron column helped to distribute the load, and, the spirals often bursted in quite distant places. When the pump was working after the maximum was reached, the concrete where the spiral bursted was destroyed and after a few minutes fell out and exposed the cast iron (see Point A in Fig. 5). Even then, the cast iron probably carried 80 per cent of the maximum load.

In two cases where the pump was kept running perhaps 10 minutes after the maximum load was reached and the cast iron was exposed for about 6 in., circular cracks appeared around the columns about 12 in. on centers, which showed the tendency of the cast iron to transmit the load by bond again into the undamaged part of the concrete, whereby the bond between the concrete and cast iron was overcome.

In column No. 4 the core of the cast iron column was filled with concrete and showed a gain proportionate to the extra concrete.

Cast iron columns No. 13 and 14 were spliced 3 ft. from the end as shown in Fig. 4. The average load carried by these two columns was 981,000 lb., while columns Nos. 11 and 14 averaged only 925,500 lb.

Columns Nos. 13 and 14 had .6 sq. in. of extra vertical steel which would account for not more than 24,000 lb. of additional strength, so that it may be safely stated splices do not diminish the strength of such columns.

Columns Nos. 15 and 16 had I-sections as reinforcement as shown in Figs. 2 and 3. The object was to find out whether a smaller radius of gyration in one direction can be counteracted by the stiffness of the concrete. These columns carried practically the same unit stresses as columns Nos. 11 and 12 with round cast iron columns.

The use of such sections may be of advantage in cases where continuous girders are attached to the columns, giving the girder bars an opportunity to pass by, or in high buildings they may be used for outside columns where great stiffness is required in one direction.

From the fact that the maximum loads of all columns were attained when the spiral reinforcement was near the breaking point, it may be inferred that larger ultimate values of the strength of these columns would have been obtained if a larger percentage of spiral reinforcement had been used. This conclusion is justified besides by the tests made by Dr. Emperger since 1911.

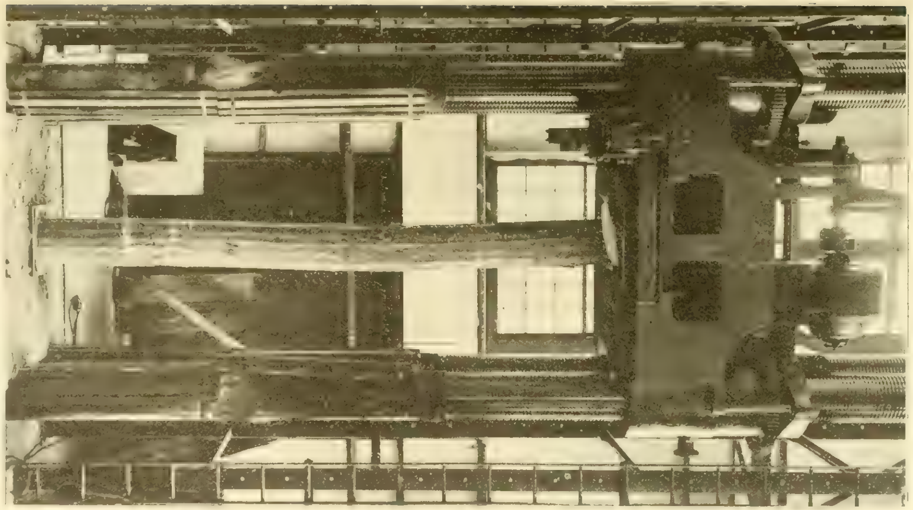


Fig. 8—Column 19 at Its Maximum Load.

European Tests of Emperger's Columns.—Table II shows the scope and the results of the most important tests. Columns II and III of this table had a core diameter of 9.6 in., a length of 10 ft. and a spiral reinforcement slightly exceeding 3 per cent. They failed at an average concrete stress of 7,500 lb. per square inch and an average stress in the cast iron of about 60,000 lb. The cast iron used was of ordinary grade.

In all other tests Dr. Emperger used high grade cast iron of an ultimate strength of 110,000 to 120,000 lb. per

TABLE I.—TESTS MADE [illegible] U. S. BUREAU OF STANDARDS' PITTSBURGH LABORATORY, NOV.-DEC., 1916. Mr. P. H. Bates in charge. Columns made in Chicago by L. J. Mensch

				Vertical reinforcement		Spiral reinforcement			Cast iron							Load considered carried—				Vertical unit deformation at		
No.	[illegible]	[illegible]	[illegible]	Bars	Area, sq. in.	Diameter and pitch	Equivalent sectional area, sq. in.	Per cent of full core area	Outside diameter	Thickness	Theoretical area	Per cent of actual concrete area	Length of column, ft.	Load at first crack, lbs.	Max. load, lb.	Av. max. load	By concrete at 4,275 lb. per sq. in.	By the cast iron reinforcement per Total	Sq. in.	Av. load per sq. in. considered carried by cast iron	½ max. load	Max. load	Strength of 6"x12" cylinder, lb. per sq. in.
[illegible]	[illegible]	[illegible]	84.8	4 ⅝* 2 ¼†	.66	No. 8 gauge 1⅛" c.c.	.69	.61	6"	¾"	12.37	14.6	6	436,500	1,057,000						.000117	.0083	4,300
[illegible]	[illegible]	1	84.8	"	.66	1⅛" c.c.	.69	.61	6"	¾"	12.37	14.6	6	776,000	1,026,000	1,041,500	405,000	636,500	51,400	51,400[1]	.0004	.0090	4,300
[illegible]	[illegible]	12	84.8	"	.66	1⅛" c.c.	.69	.61	6"	¾"	12.37	14.6	8	436,500	940,000		405,000	535,000	43,200		.00034	.0115	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		.66	1⅛" c.c.	.69	.61	6"	¾"	12.37	14.6	8	570,000	1,031,500		481,150	550,350	44,500		.000517	.0080	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	"	.66	1⅛" c.c.	.69	.61	5"	1"	12.57	13.4	8	679,000	925,000		416,600	478,400	38,100		.00035	.0071	4,150
[illegible]	[illegible]	[illegible]	[illegible]		.66	1⅛" c.c.	.69	.61	7"	⅝"	12.52	16.8	8	565,500	920,000		356,300	563,700	45,000	12,700[2]	.000366		4,150
[illegible]	[illegible]	[illegible]	[illegible]	"	.66	1⅛" c.c.	.69	.61					10	190,000	518,500						.00025		3,890
[illegible]	12¾	[illegible]	115.1		.66	1⅛" c.c.	.69	.61					10	140,000	562,200	540,350	540,350	"			.000225		3,870
[illegible]	6	4½							6"	¾"	12.37		8		480,000								
[illegible]	6	4½							6"	¾"	12.37		8		540,000	510,000	"	510,000	11,200				
11	12¾	1	84.8	"	.66	1⅛" c.c.	.69	.61	6"	¾"	12.37	14.6	10	613,500	911,000						.00035		3,750
12	12¾	12	84.8	"	.66	1⅛" c.c.	.69	.61	6"	¾"	12.37	14.6	10	650,000	910,000						.00035		3,750
[illegible]	12¾	12	84.8	8 ⅝* 2 ¼†	1.22	1⅛" c.c.	.69	.61	6"	¾"	12.37	14.6	10	776,000	896,000						.00034		4,250
14	12¾	12	84.8	"	1.22	1⅛" c.c.	.69	.61	6"	¾"	12.37	14.6	10	727,500	1,066,500	941,375	405,000	536,375	43,400		.00045		4,250
[illegible]	12¾	12	99.7	"	1.22	1⅛" c.c.	.69	.61	1	Section	13.4	13.45	10	850,000	1,071,800						.00036		4,250
[illegible]	12¾	12	99.7	"	1.22	1⅛" c.c.	.69	.61	1		13.4	13.45	10	576,000	996,000	1,069,900	476,360	533,540	39,800	11,600[3]	.00036		4,250
[illegible]	12¾	12	84.8	4 ⅝* 2 ¼†	.66	1⅛" c.c.	.69	.61	6"	¾"	12.37	14.6	12	732,500	951,500						.00037	.0070	4,250
[illegible]	12¾	12	84.8	"	.66	1⅛" c.c.	.69	.61	6"	¾"	12.37	14.6	12	630,500	909,000	930,250	405,000	525,250	42,400	12,400[4]	.00041	.0060	4,250
[illegible]	[illegible]	12	84.8	"	.66	1⅛" c.c.	.69	.61	6"	¾"	12.37	14.6	14	630,500	888,500						.00038	.0100	4,250
[illegible]	12¾	12	84.8	"	.6[illegible]	1⅛" c.c.	.69	.61	6"	¾"	12.37	14.6	14	679,000	827,500	858,000	405,000	453,000	36,650	36,650[5]	.00033	.0061	4,400

*Inch square. †Inch round. ‡Inch square. (Columns and cylinders were 62 to 66 days old when tested. Concrete mixture 1:1:2.)

[1]Probable actual load, 51,1[illegible]. [2]Probable actual load, 1[illegible]. [3]Probable actual load, 56,900. [3]Probable actual load, 47,500. Probable actual load, 16,000. [4]Probable actual load, 47,000. [5]Probable actual load, 10,500.

TABLE II.—TESTS ON EMPERGER'S HOOPED CAST IRON COLUMNS MADE BY EUROPEAN AUTHORITIES IN 1911, 1912 AND 1916.

1:2:4 Concrete.

				Vertical reinforce't.		Spiral reinforcement.			Cast iron.						Load considered carried by concrete.		Load considered carried by cast iron.		
Col. No.	Outside dia., in.	Core dia., in.	Actual area of concrete within core.	Bars.	Area.	Dia. and pitch.	Equiv. vertical area.	Per cent of full core.	Outside diameter.	Thickness, in.	Area.	Per cent of actual concrete area.	Length of column.	Max. load, lb.	Lb. per sq. in.	Total, lb.	Total.	Lb. per sq. in.	Load at first crack, lb.
Column ends enlarged to 16" in II° and III°.																			
Tests made by the Austrian Concrete Institute. See Heft No. 3, 1911 publication of above institute.																			
I°									5.67	.375	6.24		10'	307,000			307,000	49,200	....
II°	11.4	9.6	47.14	8- .197Dia.	.248	.394Dia. 1.57"c.c.	2.32	3.21	5.67	.375	6.24	13.2	10'	706,000	7,000	330,000	373,000	59,700	....
III°	11.4	9.6	47.14	.197Dia.	.248	.276Dia. .788"c.c.	2.28	3.1	5.67	.375	6.24	13.2	10'	765,000	8,000	378,000	387,000	62,000	
Tests made by Prof. Kirsch at the Royal Polytechnic School, Vienna, 1912.																			
8	5.91	5.91	9.86	6- .197Dia.	.183	.15Dia. 3.15"c.c.	1.03	3.77	4.73	.2165	3.12	31.6	35.5"	392,000	8,000	79,000	313,000	100,000	247,000
9	5.91	5.91	9.86	.197Dia.	.183	3.15"c.c.	1.03	3.77	4.73	.2165	3.12	31.6	53.2"	356,000	7,000	69,000	287,000	92,000	269,000
12	7.88	7.88	40.98	6- .197Dia.	.183	3.15"c.c.	1.375	2.81	3.15	.3465	3.06	6.25	35.5"	659,000	8,000	328,000	331,000	108,000	266,000
13	7.88	7.88	40.98	.197Dia.	.183	3.15"c.c.	1.375	2.81	3.15	.3465	3.06	6.25	53.2"	513,000	6,000	246,000	267,000	87,300	203,000
14	7.88	7.88	40.98	.197Dia.	.183	3.15"c.c.	1.375	2.81	3.15	.3465	3.06	6.25	71"	399,000	6,000	246,000	153,000	50,000	315,000
15	7.88	7.88	40.98	.197Dia.	.183	3.15"c.c.	1.375	2.81	3.15	.3465	3.06	6.25	71"	403,000	6,000	246,000	157,000	51,300	284,000
16*	7.88	7.88	40.98	.197Dia.	.183	3.15"c.c.	1.375	2.81	3.15	.3465	3.06	6.25	71"	399,000	6,000	246,000	153,000	50,000	250,000
17	7.88	7.88	31.20	.197Dia.	.183	.078Dia. 1.57"c.c.	.610	1.25	4.73	.2165	3.12	10	35.5"	569,000	6,500	203,000	366,000	116,000	274,000
18	7.88	7.88	31.20	.197Dia.	.183	.150Dia. 3.15"c.c.	1.375	2.81	4.73	.2165	3.12	10	35.5"	590,000	7,500	234,000	356,000	114,000	295,000
19	7.88	7.88	31.20	.197Dia.	.183	.181Dia. 3.15"c.c.	2.02	4.13	4.73	.2165	3.12	10	35.5"	605,000	8,000	250,000	355,000	113,600	266,000
20	7.88	7.88	31.20	.197Dia.	.183	.15Dia. 3.15"c.c.	1.375	2.81	4.73	.2165	3.12	10	53.2"	425,000	6,000	187,000	238,000	76,300	336,000
Emperger's tests, 1916.																			
3b	15.75	14.95	157			Ties					21.3	13.6	79"	2,060,000	3,000	471,000	1,589,000	74,600	1,840*
4b	15.75	14.95	157			Ties					21.3	13.6	79"	1,985,000	3,000	471,000	1,494,000	70,200	1,870*
5b	15.75	14.95	157	8-		Spiral			Cast		21.3	13.6	79"	1,910,000	3,000	471,000	1,439,000	67,600	1,810*
10b	15.75	14.95	157	.394Dia.	.97	Ties	1.24	.69%	iron		21.3	13.6	79"	2,190,000	3,000	471,000	1,729,000	80,900	2,090*
6b	15.75	14.95	157			Ties			angles		21.3	13.6	79"	1,760,000	2,000	314,000	1,446,000	67,900	806*
7b	15.75	14.95	157			Ties					21.3	13.6	79"	2,060,000	3,000	471,000	1,589,000	74,600	1,930*
8b	15.75	14.95	157			Ties					21.3	13.6	79"	2,170,000	3,000	471,000	1,699,000	77,800	1,970*

*Strength of cubes, lbs. per sq. in.

*This column had two joints at ¼ points in cast iron column and was tested with an eccentricity of .8" at the top.

square inch. This cast iron reinforcement in combination with a high per cent of hooping resulted in such high ultimate strength of the core area in compression as could have been obtained only by a solid steel section.

For example, specimen No. 8 had a concrete area inside the core of 9.86 sq. in., a cast iron area of 3.12 sq. in., or a total area of 12.98 sq. in., and failed at a load of 392,000 lb., equivalent to about 30,000 lbs. per square inch of area in compression.

Tests 3b to 10b were made on behalf of the City of Dresden, Germany, and represent in a smaller scale arch ribs of a span of 460 ft. On account of the difficulty of using spirals for such a purpose, most of the tests were made with separate hoops or ties and the percentage of hooping was limited to .69 per cent.

Although the concrete was of medium strength, these columns failed at an average stress of 12,000 lb. per square inch of core area.

ROUGH SURFACE TEXTURE CONCRETE BLOCKS FOR STRUCTURAL WALLS.

The Universal Portland Cement Co. is erecting at its cement mills at Buffington, Ind., a new sack handling building which presents features of interest both in construction methods and the pleasing effect attained in the exterior walls by the use of concrete blocks of a rough surface texture.

The building is 434 ft. long by 80 ft. wide and is one and two stories in height, two sections designed for sack cleaning being two stories high while at one end of the structure the side walls are very high to provide large space for sack storage. The general contract for this work is handled by Nash-Dowdle Co., 29 South La Salle street, Chicago.

The entire framework of the building is composed of reinforced concrete, consisting of columns, girders and purlins. The small purlins were pre-cast on the ground and then put in place between the forms for the girders and concreted in. This made possible obtaining a much smaller and more sightly purlin than if made in the usual way.

The accompanying illustration shows the framework for a large part of the superstructure. The concrete both for the columns, girders, purlins and the concrete blocks was mixed in "The Standard" low charging mixer, the portability of which enabled it to be moved around the structure and thus mix the concrete very close to where it was needed in the forms.

The concrete blocks for the exterior walls have a uniform size face of 6x24 in. and are 4, 8 and 12 in. in thickness according to the structural requirements. These blocks were made on a Hobbs machine with a Kramer automatic tamper. The surface of the block for about ½ in. in depth is composed of 1 part cement and 3 parts ⅛ to ⅜ in. limestone chips. This is thoroughly mixed with only enough water so that it will adhere when pressed in the hand and is tamped hard in the lower part of the form producing the block face. The back of the block is composed of 1:2:2 mix in which the coarse aggregate is limestone chips as above specified for the face, and the fine aggregate a coarse grade of concrete sand. By using this rich mix, mixing the concrete for the back of the block comparative wet and tamping it hard into the mold, a block of excellent density is produced.

Construction View of New Sack Building at Buffington, Ind.

The unique feature of this method of block construction is that a surface texture is obtained which compares in artistic effect with the rough surface monolithic concrete construction which has been greatly admired in the structures erected by the South Park Commissioners of Chicago. The great density of these blocks makes them least effected by moisture.

HEAT TRANSMISSION THROUGH WINDOW SASH.

Experiments to determine the relative heat loss through single and double-glazed wood, steel and hollow metal sash have been conducted recently under the direction of Mr. Arthur N. Sheldon. In a paper read before the American Society of Mechanical Engineers, and printed in the January proceedings, Mr. Sheldon gives the results of his tests.

Tests were conducted on seven samples of sash, as follows: No. 1, single-glazed, solid rolled steel; No. 2, double-glazed, solid rolled steel with ¾-in. air space; No. 3, double-glazed, solid rolled steel, with 3/16-in. air space; No. 4, double-glazed wood; No. 5, single-glazed wood; No. 6, double-glazed hollow metal; No. 7, single-glazed, hollow metal sash.

Tables I and II summarize the comparative heat-transmission rates.

Figure 1 also shows the results of the tests plotted in the form of curves. It will be noted from the curves that the rate of transmission increases with the heat head—temperature difference between outside and inside air—and that there is a greater increase for the single than for the double-glazed sash.

In order to obtain an indication of the paths of heat transmission the temperatures of the glass and sash bars were taken during each test. It was found that for a given temperature difference the solid steel sash bars were hotter than the wooden bars, and by their greater conductivity constituted a direct path for the transmission of heat to the outside air. The hollow metal sash bars were cooler than the solid steel, but warmer than the wood. Indirectly, a further heat loss through the glass itself, in the case of double-glazed sash, can be laid to the solid steel section. Since the amount of heat lost through a given pane of glass depends directly upon the difference in temperature between the two sides, it is evident that in a double-glazed sash the rate of heat transmission through the lights must increase with the temperature difference between the air space and the outside air. The tests showed that the temperature difference between the air in the ¾-in. air space of the steel sash and the outside air was at least 20 per cent higher than the corresponding temperature difference in a wood sash, evidently due to the effect on the enclosed air of the warmer steel sash bars.

TABLE I—HEAT TRANSMISSION RATES AT APPROXIMATELY 40° F. TEMPERATURE DIFFERENCE.

Sample.	Actual heat head, ° F.	H computed at actual heat head.	H corrected to 40° F. heat head.	Relative humidity.	Condensation.
1. Single-glazed solid steel	41.5	29.3	28.5	36	None.
2. Double-glazed solid steel—¾-in. air space	37.4	20.4	20.5	34	None.
3. Double-glazed solid steel—3/16-in air space	45.7	22.8	22.5	13	Very slight on air space side of one outside pane and box side of one inside pane.
4. Double-glazed wood —⅝-in. air space	47.3	14.2	13.9	19	None.
5. Single-glazed wood	41.2	25.6	25.5	44	Hardly noticeable.
6. Double-glazed hollow metal — ¾-in. air space	43.9	15.4	15.2	54	On air-space side of one outside pane.
7. Single-glazed hollow metal	46.0	27.1	26.4	13	All.

TABLE II HEAT TRANSMISSION RATES AT APPROXIMATELY 70° F. TEMPERATURE DIFFERENCE

Sample.	Actual heat head, ° F.	H computed at actual heat head.	H corrected to 70° F. heat head.	Relative humidity.	Condensation.
1. Single-glazed solid steel	73.9	31.2	33.6	28	All
2. Double-glazed solid steel—3A16-in. air space	76.8	21.8	21.6	29	Fifteen outer panes out of 20 showed moisture on air-space side.
3. Double-glazed solid steel—3/16-in. air space	76.0	21.2	21.0	30	One outer pane showed moisture on air space side one inner pane showed moisture on box side. Three lights showed both the above
4. *Double-glazed wood —⅝-in. air space	79.8	15.5	15.1	31	None.
5. Single-glazed wood	67.6	28.9	29.3	9	Twelve lights
6. Double-glazed hollow metal—¾-in. air space	75.6	16.6	16.1	36	On air-space side of one outside pane.
7. Single-glazed hollow metal	77.7	30.5	29.7	25	All.

*A test upon this same wood sash with the inside panes of single-thick plain glass instead of double-thick showed an increase in H of 3 per cent at 70° F. temperature difference

Tests also were conducted to determine the cause of condensation in double-glazed sash and its prevention. Condensation appeared on the single-glazed sash when its temperature was low enough to cool the air confined within the test box below the dew point. The moisture was evident on the inside of the panes. Where condensation occurred in the air space of double-glazed sash, it was always on the outside pane of glass. The wood sash showed no internal condensation, but in the steel sash condensation was very marked, and was evident in the hollow metal samples. The deposition of moisture seemed to follow no obvious law, occurring on some lights and not on others. As this inconsistency was most pronounced on the solid steel sash, they were selected as the most suitable for investigation. The steel sash, with a ¾-in. air space, was chosen for the preliminary tests, experiments being also conducted afterwards on the hollow metal and wood sash to verify or disprove the previous conclusions.

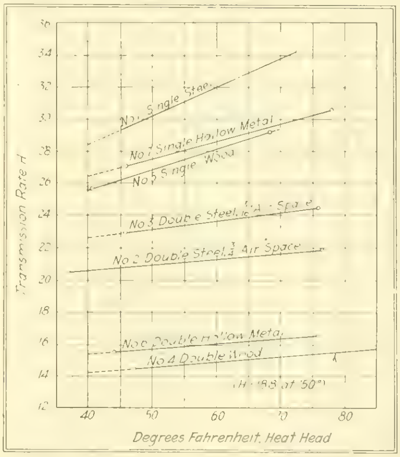


Fig. 1—Heat Transmission Rates Through Various Types of Sash

Holes were bored through each of several of the outer panes of wire glass, of which some had and some had not shown condensation. Smoke was then blown into the various air spaces through these holes and leaks to the outside or to adjacent air spaces carefully noted. Considerable leakage was observed, either to adjacent air spaces or to the front or back or to a combination of these. It was observed that in lights where condensation was evident the greatest leakage was into the inside of the box, and that in those lights where no condensation occurred the greatest leakage was to the air outside the box. Other lights showed serious leaks to both sides and to adjacent air spaces and also showed condensation.

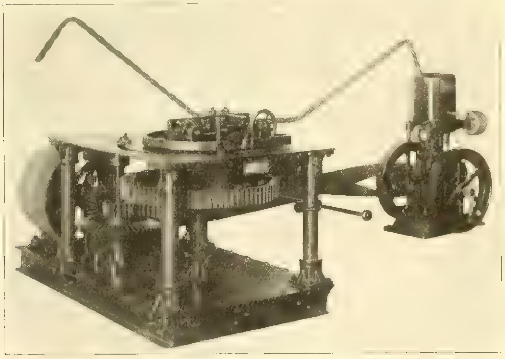
Following this clue, the entire sash was reglazed and holes bored in seven of the outer panes, and in five of the inner panes, thus establishing free communication either to the external cool or to the warmer air inside the test box. All the other panes were carefully bedded and set so as to be air-tight. A test on this sash showed the following results: Lights in which the air space opened to the outside or cooler air only showed no condensation; lights in which the air space opened to the warm air inside the test box showed much condensation. The sash was reversed, with its out side toward the interior of the test box, and the above results were confirmed.

The double-glazed wood sash, when tested in the same manner, showed no traces of condensation in any of the air spaces.

The experiments indicate that condensation in the air space of double-glazed sash can be eliminated almost entirely by connecting the air space directly to the outside air and at the same time effectively sealing it from the entrance of the warm air within the building. It is suggested that the openings should be very small, equivalent, say, to a ⅛-in. hole, designed merely for a communication between the internal air space and the outside air during temperature changes. This "breathing hole" should be protected from the weather and dirt. Its location seems to be immaterial from the standpoint of elimination of condensation, but a consideration of heat economy would indicate that the bottom of the light is preferable. Whether or not, as a practical problem, this method can be applied to seal the inside panes of double-glazed steel sash, and leave an opening in the outside panes, is worthy of the careful consideration of steel sash manufacturers. The results of these tests should not be construed as indicating that double-glazed wood sash never show interior condensation, but merely that they are superior to steel and hollow metal sash in this respect in the present stage of development of the latter types.

POWER BENDING MACHINE FOR REINFORCING RODS.

A portable bar bender capable of bending rods up to and including 1¼ in. in diameter has been placed on the market by the McKenna Power Bar Bender Co., of Cleveland, O. The machine has a structural steel base and all wearing parts are cast steel. It weighs 1,800 lb. and occupies a floor space 4 ft. x 7 ft. It is operated by a belt driven gasoline engine or by a motor, about 5 h. p. being required. The bender has a vice arrangement for keeping the rod in alignment when making more than one bend. It also has an automatic stop that can be set for any degree of curvature. The machine will bend column rods for the mushroom system. It is operated by one man.



Portable Power Bar Bending Machine.

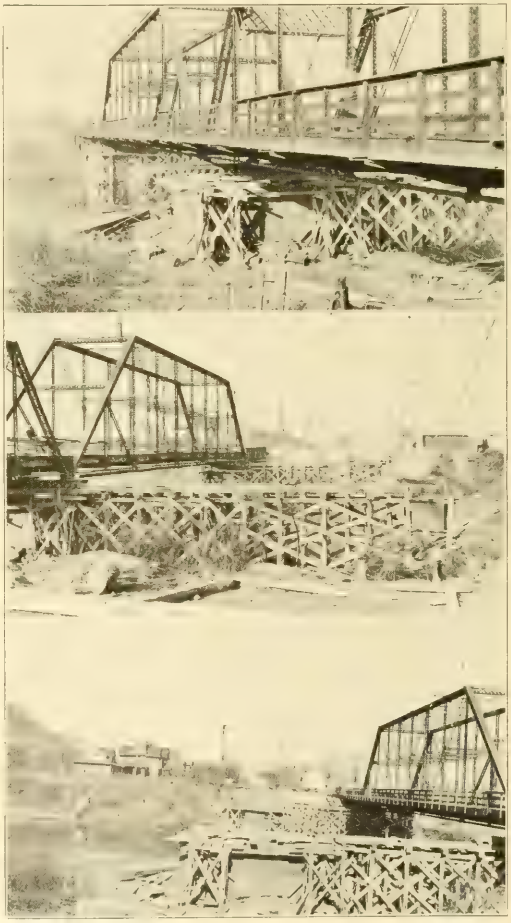
A bill has been introduced in the State legislature of New York providing for the establishment of a State Water Power Development Commission to consist of the State engineer and surveyor, conservation commissioner, attorney general and superintendent of public works. The Commission would investigate the character, value and extent of surplus waters of the State available for power purposes, and would report to the legislature by Feb. 1, 1918.

METHOD OF MOVING A 3-SPAN STEEL BRIDGE.

In connection with the construction of a new concrete bridge over Stony Creek at Johnstown, Pa., the old structure was moved to a new location, where it will serve as a temporary crossing.

The old steel bridge consisted of a 100-ft. Pratt truss span, a 175-ft. Pratt truss span and a 61-ft. plate girder span. The total weight of the three spans was 405 tons. The roadway was 21 ft. 8 in. wide and carried two street car tracks. There also was a 6-ft. sidewalk.

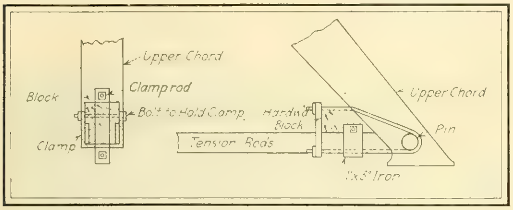
The bridge was moved on runways brought to roller level on falsework and pile bents, as shown in the accompanying illustration. At the piers 3-post bents 5 ft. wide at the top were built 14 in. below the bridge seat. The bridge was then raised 2 in. by two 30-ton, one 150-ton and one 250-ton jacks and enough stone substructure torn out to allow the insertion of I-beams and rollers. The shore ends were loaded on 10-in. x 12-in. timber and the floor blocked on top. A 3-in. skid and 5 rollers were placed under each girder. Ten 9-in. I-beams and 18 6-in. wooden rollers were used under one end of the 175 ft. span and ten 8-in. I-beams and 18 7-in. rollers were used under the other end. The rollers were spaced 18 in. apart.



Top View: Completed Bents; Bridge Loaded Ready to Move. Middle: Jacking Towers, I-Beams and Rollers. Lower: Showing Old Piers and Bridge in New Position.

The bridge was moved by means of capstans and house-moving equipment. A capstan was placed at each end of the structure and connected by cables to the bridge posts. The drums on which the cable was wound had a 10-ft. sweep and were pulled by horses.

There was no interruption of street car, vehicular or foot traffic during the loading of the bridge. The three spans were moved at the rate of 7 ft. in 10 minutes, but on account of the interference of poles the work had to be stopped to make changes in hitches. The I-beams were used because the contractor had them on hand and was short of rollers. When the rollers were past the load the I-beams were jacked up and the rollers moved ahead. The entire time consumed in moving the bridge, a distance of 54 ft., was 2 hours and 20 minutes, this including the delays waiting for engineer to give points for the final placing of the structure. There were no unusual stresses placed on the old structure nor does it show any bad effects from its change. The moving was in charge of R. D. Horney, superintendent of the Hackedorn Contracting Co., Indianapolis, the contractors for the new concrete bridge. Mr. Horney was assisted by J. D. Strayes of Johnstown, who furnished and handled the capstans and house-moving equipment that was used.



Sketch of Arrangement Under Which Jack Was Placed. This Wedged Tension and Upper Chord Members Together, Making them Lift as One Solid Piece.

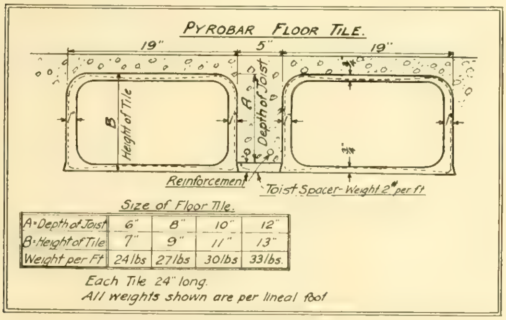
FLOOR FILLER TILE MADE OF STRUCTOLITE GYPSUM.

Contributed.

An article in the Dec. 27, 1916, issue of Enginering and Contracting outlined the possibilities of reinforced "Structolite" gypsum construction as applied to roof decks, eliminating the use of steel purlins and spanning from truss to truss, a distance of 10 ft. or more.

Attention is here drawn to another use of reinforced "Structolite" which consists of a specially prepared and reinforced gypsum floor filler tile which is used in combination with reinforced concrete "T"-beam long span floor construction.

Figure 1 illustrates the use of these floor fillers in connection with reinforced concrete, and also tabulates the depth of tile necessary when 6, 8, 10 and 12 in. concrete beams are considered.



Size of Floor Tile.

A-Depth of Joist	6"	8"	10"	12"
B-Height of Tile	7"	9"	11"	13"
Weight per Ft	24 lbs	27 lbs	30 lbs	33 lbs.

Each Tile 24" long.
All weights shown are per lineal foot

Fig. 1—Floor Filler Tile With Reinforced Concrete.

It will be noted that in each case the filler tile has a depth 1 in. greater than the depth of concrete joist. This makes provision for the insertion of a gypsum soffit piece at the bottom of the concrete beam which acts as a spacer (during construction) for the floor filler tile, and when the forms are removed leaves an all gypsum ceiling surface suitable for factory buildings and an excellent base for the plaster coats where a plastered ceiling is desired.

Since "Structolite" gypsum floor fillers are a reinforced product with high compression value, wheeling and similar working operations can be conducted over these tile during the pouring of concrete. At a recent demonstration test a 6 in. tile carried without failure the weight of 14 men uniformly distributed upon a plank covering the entire tile and extending beyond the ends. This load amounted to about 664 lb. per sq. ft. of tile surface. This strength, and the fact that the tile are reinforced makes possible a thinner concrete floor slab between "T" beams.

Another feature in the use of these floor fillers lies in the fact that the ends are closed, and the tile being a cast product, in all cases and at all points of contact fit so closely as to preclude the possibility of any appreciable waste of the poured concrete mixture.

The cost of necessary form work by this construction is reduced to a minimum as will be seen from Fig. 2, where it is shown that for all purposes less than 2 ft. B. M. of lumber is necessary per square foot of floor area. Also, all lumber used can be re-used or is good for salvage since all parts of the form work are protected and do not come into contact with the concrete. Open form work also lends itself to operations through the filler tile (which are easily bored or cut) for piping, conduits and similar necessities.

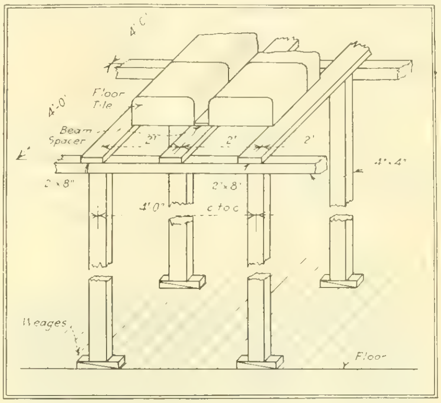


Fig. 2—Form Work for Floor Construction.

A series of tests to determine the effect of "Structolite" gypsum floor tile upon the strength of concrete made and aged in contact with it were conducted from March 27th to June 21st, 1916, by the R. W. Hunt & Co. Testing Laboratories, Chicago.

In all 27 tests were made as follows:

9 tests upon the strength of concrete made and set in contact with gypsum floor tile that had been wetted.

9 tests upon the strength of concrete made and set in contact with dry gypsum floor tile.

9 tests upon the strength of concrete made and set without any contact of gypsum floor tile.

Table I gives the crushing strength of concrete under these conditions for the periods stated. In all cases where

TABLE I.

	Concrete set in contact with Structolite gypsum floor tile.		Concrete set without Structolite gypsum floor tile.
	Wetted tile.	Dry tile.	
7-day crushing strength of concrete (lb. per sq. in.)	1,771 1,568 1,785	1,654 1,741 1,746	1,417 1,550 1,452
Average (lb. per sq. in.)	1,708	1,711	1,473
28-day crushing strength of concrete (lb. per sq. in.)	3,978 3,955 3,919	3,289 3,121 2,789	2,953 [illegible] 3,657
Average (lb. per sq. in.)	3,951	3,066	3,360
3-month crushing strength of concrete (lb. per sq. in.)	4,836 5,648 4,894	3,519 3,778 3,518	3,720 [illegible] [illegible]
Average (lb. per sq. in.)	5,126	3,605	3,636

Note—Concrete mixture consisted of 1 part of Portland cement to 2 parts of torpedo sand to 4 parts of crushed limestone (¼ in. to 1 in.) by volume the concrete was made and set in contact with dry or wet gypsum floor tile, the tile was entirely stripped from the concrete before the crushing test.

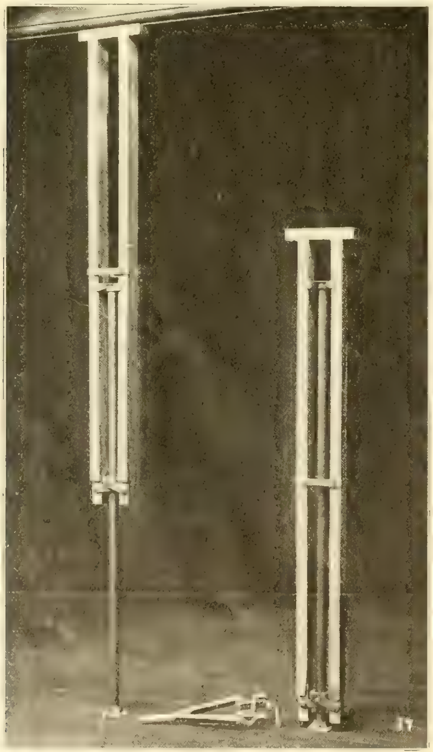
An examination of Robert W. Hunt's tests shows that for the 7-day period concrete allowed to set in contact with wetted gypsum tile is 16 per cent stronger than when set alone. This is of particular interest for this increase in strength takes place when it is most needed, viz., during the safe removal of form work. For the 28-day period the increase is over 17 per cent, though there is a decrease of about 8 per cent when the gypsum tile was not previously wetted.

For the 3-month period the increase in strength is over 40 per cent more than concrete setting alone, and practically the same for concrete setting alone or in contact with dry gypsum floor tile.

The deductions from this test data are, that the gypsum floor tile in contact with concrete prevents the too rapid drying out of the concrete, and in giving back any excess of moisture due to wetting, supplies conditions favorable to a harder mass.

A SELF-LOCKING ADJUSTABLE SHORE.

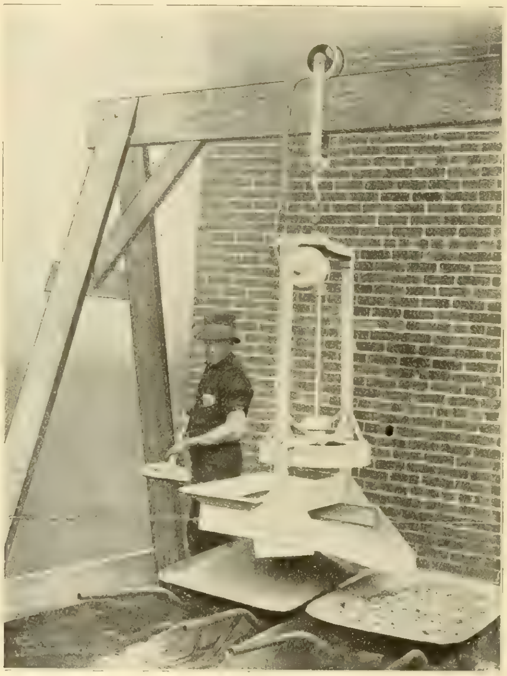
One of the new exhibits that attracted considerable attention at the recent Chicago Cement Show was a self-lock adjustable shore. This shore consists essentially of a lower member of standard pipe and an extension member of two legs of 2x4's with attached clamping yokes which engage with the pipe. The shore for average use is made up of a 7-ft. piece of pipe and two pieces of 2x4's 8 ft. in length. This gives a shore adjustable from 8 ft. to 14 ft. In using the shore it is only necessary to lift the upper member to the form above and press the two wooden uprights together. This causes the yokes to grip on the pipe. For firmer adjustment the shore can be raised with a jacking device. To remove the shore it is only necessary to release a set screw and tap the yokes with a hammer. The device is known as the Roos Self Lock Adjustable Shore. It is made by the H. W. Roos Co., Stanton Ave., Walnut Hills, Cincinnati, O.



The Roos Self Lock Adjustable Shore.

A SAND SCREENING DEVICE.

A gyratory riddle for screening sand for construction purposes is illustrated below. Two separations are made by the device, the screened sand passing through the sieve and the gravel, or refuse, tailing off to one side. The capacity of the machine, of course, depends on the material to be separated. As a general proposition, it is stated, that it will sift sand faster than a man can shovel it in. The riddle shown is operated by a 1/3 h. p. electric motor. The manufacturers, however, have in contemplation a similar machine arranged to be driven by a gasoline motor or from a line shaft. The device is known as the Combs Gyratory Riddle. It is made by the Great Western Mfg. Co., Leavensworth, Kan.



The Combs Gyratory Riddle.

PERSONALS.

Towl Engineering Co., civil engineers, has changed its offices from 1119-22 City National Bank building, Omaha, Nebr., to 1420-1 First National Bank building, Omaha.

Eugene W. Stern, chief engineer of highways, Borough of Manhattan, New York City, has been commissioned by President Wilson a major in Engineer Officers, Reserve Corps, U. S. Army.

W. A. Hey and B. H. Keeler have organized the Hey-Keeler Construction Co., with offices in the Black Hawk building, Waterloo, Ia. Mr. Hey formerly was connected with the Miller-Hey Co., contractors, Waterloo, Ia., and Mr. Keeler for the past ten years has been superintendent and chief engineer of the Crane Construction Co., Kansas City, Mo.

J. H. Libberton, 210 S. La Salle street, Chicago, was elected secretary of the American Concrete Pipe Association at its annual meeting Feb. 15. Mr. Libberton is division engineer of the Promotion Bureau of the Universal Portland Cement Co. He succeeds E. S. Hanson, editor of the Cement Era, who has been secretary of the association since 1913, when the association was formed.

INDUSTRIAL NOTES.

The technical staff of Wallace & Tiernan Co., Inc., New York City, on Feb. 2 celebrated by a dinner the 500th installation of that company's chlorine control apparatus. Many prominent water works men and sanitarians were guests of the evening and very interesting remarks were made dealing with the early days of chlorination and the first installation of W. & T. equipment. A souvenir menu illustrated the growth of the organization. A picture therein showed Mr. Wallace and Mr. Tiernan with the first chlorinator, and another showed a portion of the present staff with the 500th machine, mention being made of district offices in Chicago, Dallas, San Francisco and London.

Road and Street Issue
of
Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

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Volume XLVII. CHICAGO, ILL., MARCH 7, 1917. Number 10.

HOW THE READERS HAVE WELCOMED THE ROTATED SPECIAL MONTHLY ISSUE FEATURE OF "E. & C."

Exactly eight months ago this periodical made one of the most radical changes ever attempted in the field of journalism, by so grouping its articles as to produce four rotated special monthly issues of a weekly paper. Within a month after the change was initiated there was clear-cut and sufficient evidence to convince us that the old readers welcomed the change. Within three months it was equally certain that the subscription campaign for new readers was a pronounced success.

Now, after two-thirds of a year have elapsed, we are able to say that never before in the eleven-year history of E. & C. have we secured such excellent subscription returns. We have averaged more than 30 new subscribers for every 1,000 sample copies, or 3 per cent returns. Not only does this break every subscription campaign record of our own but of every other similar campaign of which results have been made public. We are speaking now of a long-sustained campaign, and not of the subscription results from a few issues.

Engineering and Contracting has never made a practice of selling subscriptions through the solicitation of agents, in spite of the fact that that is the cheapest way of securing new subscribers. Our reasons for adhering to the sample copy method of campaigning for new readers are these:

First, because an engineering or contracting periodical that cannot "sell itself" is either lacking in merit, or reaches a man who is not sufficiently interested in the sort of reading matter that it presents.

Second, because a temporary subscriber is not a particularly desirable subscriber; and "permanence" is about the last thing to be expected of a subscriber secured by personal solicitation. The periodicals that employ subscription canvassers fail to renew 35 to 40 per cent—often more—of their subscribers without resort to another personal solicitation.

Third, because sample copies are effective in bringing inquiries for catalogs, prices, etc., of things advertised. It would be pure hypocrisy for a publisher or editor to deny the necessity of the financial support of advertisers. Nowadays few readers fail to realize that subscribers are an "asset" to the publisher in proportion as they let advertisers know that the advertising is effective. This leads us to remark that modern advertising of technical products is becoming more and more informative, and consequently more valuable. Time was when advertising pages were mere directories. Even then they were valuable, but now they are directories plus—plus suggestive pictures, usable hints, and really educational information.

In another column we print some letters from subscribers, typical of many others, in comment upon our plan of publishing four rotated special monthly issues and one quarterly issue of "E. & C." These letters indicate a surprisingly general approval of the new plan. We say surprising, for it is rare indeed that any change does not call forth quite a large percentage of disapproving letters from subscribers. The disapprovals thus far received have been less than four per hundred.

Representatives of a certain engineering periodical have been alluding to our changed method of publication as "a sign of weakness." Well, all life is "a sign of weakness," and evolution through change is itself "a sign of weakness." Inanimate, unchanging things—mountains, Egyptian pyramids and fossil periwinkles—are "signs of strength" and permanence. Each in its place is good, but the living thing that does not change already has its ultimate "place" marked and partly dug. The life in a periodical is the life of its business and editorial staff. When that "staff" ceases to promulgate new ideas, keeping abreast and even slightly ahead of the times, the monument cutters will soon be chiseling another "Rest in Peace."

HOW A ROAD CONTRACTOR MAY GET BUSINESS WITHOUT BIDDING FOR IT.

Competition in roadwork is usually so keen that an experienced contractor often finds it impossible to be "low bidder" and yet have enough profit in sight to pay him for his time. The editor found himself in this dilemma some years ago. How he extricated himself may be of interest.

There are many counties, villages and small towns where highway improvement is contemplated, but where the work has not been surveyed and estimated. The writer's plan consisted, first, in finding a locality of this sort, and, second, in offering to make a survey and an estimate of the cost at which he would undertake to do the work himself. In the event that the work were let to another contractor, he only asked a stipulated sum for the survey and plans to cover their actual cost. By naming this sum for the survey and plans in advance, and by making the price moderate, it was frequently possible to secure an order to proceed with the survey.

The next step involved securing approval of the proposed plans by a local or nearby engineer under whose direction the work could be done, the local engineer to receive a percentage of the estimated cost as his fee. This is a matter not difficult to arrange.

The third step involved the securing of an authorization to proceed to a letting of a contract for the work. This was often a stumbling block of no mean proportions. Occasionally action was secured by offering to take short-term bonds in payment for the work.

In the case of villages, paving can usually be done by abutting property owners without a public letting. Then the contractor's main difficulty consists in bringing enough of the property owners along a street to the same point of view at one time—and that point of view one favorable to the contractor's plans. The writer found an effective means in such a case to be a comparison of the cost per linear foot of paving on other streets with the price that he was prepared to name. His general design of highway was one that made such a comparison very favorable to himself. In brief, it consisted in paving only 16 to 18 ft. of the center of the street, graveling the shoulders to the gutter, and omitting curbs. The pavement usually was a macadam 6 in. thick on poor soils and 4 or 5 in. thick on good soils. By showing photographs of streets thus paved, it was usually practicable to convince taxpayers that a dirt or poor gravel street could be vastly improved at comparatively low cost.

In cases where a lump-sum or unit-price contract could not be secured without open competition, it is often a good plan to do the work at "cost plus a fixed sum," the "fixed sum" being the contractor's profit. But this form of contract for highway work does not appeal so strongly as one that definitely limits the total cost. To meet a desire for such a contract and at the same time to demonstrate that the contractor is seeking only a fair compensation for his services, the limited-cost-with-a-penalty-profit-contract has been devised. Under this form of contract the contractor agrees to do a specified job at cost plus a percentage for profit, but when the cost and percentage exceed a specified total sum, then the excess is to be taken out of the contractor's profit so long as any profit remains. This is an exceedingly attractive form of contract, for while it does not absolutely limit the total cost it does spur a contractor to do his best, which, if the contractor is at all capable and experienced, is almost certain to result in a total cost within the estimated limit.

Through the news columns of engineering and contracting papers, supplemented by clippings from local papers, a contractor can ascertain what highway work is in contemplation, and he can often create work for himself as above outlined. But he should not limit himself to work that has reached the stage of being talked about in the public press. He should industriously promote highway work where it is evidently needed, and where the community can afford it, but is too lethargic to act without external leadership.

The days of the contractor-promoter are by no means ended, and probably never will be. A combination of wit, energy and a really good business proposition will generally meet with satisfactory reception.

WHAT THE WAR HAS DONE TO ESTABLISH THE "FUNDAMENTAL LAW OF MANAGEMENT."

In a paper entitled "The Science of Management Engineering," read Dec. 14, 1909, before the American Society of Engineering Contractors, the editor of Engineering and Contracting said:

> As I conceive it, the fundamental law of successful management is this: To secure maximum output make all payments for work proportionate to work done.

And again in "Cost Keeping and Management Engineering," by Gillette and Dana, it is said:

> The fundamental law of management involves that payment for work done shall be proportionate to performance—that is, an increased number of units of work done by a man shall result in his receiving increased pay. The ordinary wage system is based upon this law, but only in a very crude manner, since it throws men into large groups or classes, individuals of which receive the same pay, or practically so.

The managerial law of payment proportionate to performance has been overriden for centuries in Great Britain, first by the trade guilds, later by the modern labor unions. British industrial efficiency has been, in consequence, held in check in spite of the inventiveness of the English race. It has remained for the bloodiest cataclysm in history to act as a means of disclosing the full stupidity and individual iniquity of the labor union leaders who have been restricting the output of union members.

In a momentous address to the House of Commons, Feb. 22, Lloyd George proved his courage not only by laying bare the food conditions that menace the empire, but by his remarks about labor union restriction of output. He uttered what seems to be the greatest single advertisement yet shown to the world as to the effect of the piece-rate payment on the output of workmen:

> "Wherever payments by results have been introduced," said the premier, "there has been an increase in the output of shipbuilding yards, sometimes by 20, sometimes by 30, and sometimes even by 40 per cent. We have made a special appeal to the great trade unions to assent to the introduction of these methods. In some yards they have already been introduced. This also involves the undertaking by employers that if larger wages are earned by the men as a result of special efforts no advantage must be taken of that to reduce rates. The penalizing of good work by reducing the rate of payment has been one of the great follies of the past that have caused the working man to fear piece rates."

Note that already the increased output of men in shipyards has been increased 20 to 40 per cent "wherever payments by results"—payments in proportion to performance—have been introduced. Every student of the science of management could safely have predicted such a result, for the experiment of payment proportionate to performance has been tried so often, and the results have so uniformly indicated a greatly increased output, that no economist could doubt what would happen in English shipyards.

Incidentally, it is worth while noting that the great apostle of "scientific management," the late Frederick W. Taylor, roundly condemned piece-work payment, even in his latest writings ("The Principles of Scientific Management," 1911). He says (page 23):

> It is, however, under piece-work that the art of systematic "soldiering" is thoroughly developed. . . . The feeling of antagonism under the ordinary piece-work system becomes in many cases so marked on the part of the men that any proposition made by their employers, however reasonable, is looked upon with suspicion, and "soldiering" becomes such a fixed habit that men will frequently take pains to restrict the product of machines which they are running even when a large increase in output would involve no more work on their part.

Mr. Taylor advocated his own "differential piece-rate" method of payment, and failed to generalize the broad law of payment proportionate to performance. Indeed, the prime defect of his "system" is its narrowness. He never attempted to broaden it until 1911, about 16 years after he wrote his celebrated paper, "A Piece-Rate System," and 8 years after his greater paper, "Shop Management," and then he was unable to escape the narrowness of his original conceptions.

The old straight piece-rate system has no inherent defect such as Mr. Taylor attributed to it. Wherever it has failed to increase the output of workmen it has been because it was so operated by employers as not to increase the ultimate income of the workmen. In short, the hoggish short-sightedness of employers caused the "soldiering" that Mr. Taylor regards as a necessary adjunct of the straight piece-work system. Yet since the same hoggishness may result in cutting the rates of pay under any system—even Mr. Taylor's—it follows that the piece-work system is not in itself the reprehensible system that it has been painted.

And now we have Lloyd George's statement that piece-work systems are producing remarkable increments in the output of British workmen. Obviously the workmen feel that, with the British government backing the piece-rate system, they are going to be assured against a reduction of rates as soon as they increase their output. Is there not food for deep contemplation in this very fact? May it not be wise to exercise governmental authority in the fixing of piece-rates wherever labor unions and employers cannot agree?

THE ECONOMY OF SURFACING OLD MACADAM STREETS WITH ASPHALT PAVEMENT.

The surfacing of old macadam with an asphalt pavement is not a new practice, but it has received less publicity than it really merits. The editor recalls seeing streets in Buffalo 20 years ago that had been built in this manner. They were among the smoothest and best streets in the city.

More than three years ago (1913), 5,000 sq. yd. of old water-bound macadam street were covered with a 3-in. asphalt pavement, which is today as smooth as the day it was laid. In 1915 about 36,000 sq. yd. and in 1916 about 92,000 sq. yd. of old macadam were similarly resurfaced with 3-in. asphalt.

The preparation of the old macadam surface was done by city forces at a cost not stated. The contract price of the asphalt surface laid in 1916 averaged less than 90 ct. per square yard. The asphalt consisted of a 1.5-in. binder course and a 1.5-in. wearing surface. The contract provides a 5-year guarantee.

The old macadam was scarified as little as possible, on the theory that it should not be disturbed if it could be avoided. Hence most of the grading was done with the "binder course," although it was recognized that excessive thickness of "binder" is apt to result in a subsequent compacting that will leave a depression.

We are of the opinion that where the old macadam is irregular it should always be scarified, leveled with a harrow and re-rolled before the asphalt paving is laid. The editor has fully described the methods and cost of such work done under his direction (see Handbook of Cost Data, page 288, etc.). Such surfacing of macadam can be done for 2 to 3 ct. per square yard, and it can be so well done that the finished macadam surface is very uniform and as solid as a rock. It takes much less rolling to compact a scarified macadam than it does to compact a new macadam. And with the aid of a heavy harrow the leveling of the scarified surface is speedily and cheaply accomplished. This last fact is not generally known.

Macadam makes an excellent base for any kind of pavement. Whether it should be used or not is entirely a matter of cost per square yard. When macadam is already in place and needs only resurfacing, there can be no question as to the economic wisdom of using it, as it is being used in New Haven, under the direction of Mr. Frederick L. Ford, City Engineer.

"WHERE IS THE MONEY COMING FROM" FOR ROADS?

Engineering Record puts this query in connection with certain statistics. The revenue available for road purposes was about $37 per mile in 1904 and $98 per mile 10 years later, "an increase of 165 per cent." During the same period the financial burden on the taxpayer rose from 23 ct. to 35 ct. per $100 of assessed value, "an increase of only 52 per cent." To complete the story we should have a statement of the rise in value of farm lands, which, if our recollection serves us aright, was almost double.

"Where is the money coming from?" From the savings effected by the building of better roads, which are largely reflected in the rise of farm land values. If a farmer can add 100 per cent to the value of his farm by adding 50 per cent to his road tax of one-quarter of 1 per cent, he can speedily answer the question as to "where is the money coming from"?

The great trouble has been that the average farmer's eye has been so hypnotized by a penny of tax that you could not divert his attention to a dollar of increased value in his land, even when you "hollered." However, the hynoptic spell of the tax has begun to weaken, and we urge our contemporary not to aid in its revival by the old tax-fearsome cry: "Where is the money coming from?"

EDITORIAL COMMENT.

During 1916 there were built 1,158 miles of "State aid" roads in Wisconsin, at an average cost of $3,140 a mile. The surfacing used was mostly gravel.

More than 25,000,000 sq. yd. of concrete pavements were laid in 1916, of which about two-thirds was on country roads.

Will very heavy motor-trucks be restricted to certain streets whose pavements are designed to carry the heaviest of loads? This may come about in every city. The city council of Cleveland has ordered the Commissioner of Engineering to lay out motor trucking routes in the residence districts, with a view to protecting the thin pavements, of which there are so many.

It is stated that a single-track, 10-ft. wide, macadam road built in Adams County, Indiana, was a failure, because mud was tracked onto it from the earth roadway alongside, and the mud caused holes to "burn" through the macadam. On the other hand, a 14-ft. wide macadam on a 16-ft. roadbed has been a success. We offer the suggestion that even the 10-ft. macadam might not have been a failure had macadam or gravel turnouts been provided every 500 to 600 ft.

AN EXPERIMENT IN ESTABLISHING GRADE LINES FOR ROAD CONSTRUCTION.

To the Editor: It may be of interest to some of your readers to know of a little experiment which we tried out in this office in the establishing of grade lines for State aid roads.

At a conference of the division engineers of the Illinois Highway Department held in Chicago Feb. 9, 1917, Mr. Bilger, Road Engineer, suggested that he doubted if we as yet realized the true economics of the establishing of grade lines and the computation of earthwork quantities in road work. At his suggestion I agreed to try out an experiment along this line as follows:

Our regular scale for profiles is, 1 in. equals 8 ft. vertical and 1 in. equals 80 ft. horizontal, or a distortion of horizontal to vertical of 10 to 1. This scale works in exceptionally well with our filing system and it was hardly thought necessary at this time to consider changing this scale. However, there was worked up in this office, grade line and earthwork computations on 53 Stations of road on Route 5, Moultrie County. This road was to be 10-ft. concrete slab in the center and 10-ft. earth shoulders on each side, making a total width of graded road 30 ft. When this grade line was plotted using our regular scale quantities for the 53 Stations there were 3,474 cu. yd. of earth excavation in cut. After two or three weeks the same man plotted this profile on a scale 1 in. equals 8 ft. vertically, but changing the horizontal scale so that 1 in. would equal 16 ft., making the distortion between the horizontal and vertical scales only 2 to 1. He replotted this grade line and computed quantities of excavation and the cut amounted to 2,831 cu. yd., showing a saving of 643 yd. of excavation by using the more nearly natural scale.

This road is on gently rolling country and black loam soil. The reason, of course, for the difference in the two methods is due to the fact that when the scales are so greatly distorted it is a constant temptation for the men plotting the grade line to want to cut off every bump that appears on the ground line. When the scale is plotted to more nearly natural scale the men see that the grade could be laid along the ground practically as it is without causing any bad effects after the road is constructed.

The grade line was plotted up for experimental purposes, using ordinary profile paper and the extra work of actually plotting and checking the profile amounted to probably about one man-hour. The time consumed in laying the ground line and computing the earthwork computations, using the distorted scale, was 8½ hours, which was slightly longer than it should have been. The time consumed by the same man in laying the grade line on a more nearly natural scale was 5¾ hours. I think this was possibly due to the fact that it is easier for a man computing earthwork computations to keep his cuts and fills balanced where he is following the groundline very closely than where he is making small cuts and fills.

After the quantities had been computed, using the more nearly natural scale, the grade line was replotted on the regular plan and profile paper and will be the grade used when this road is constructed during the coming summer. I have no doubt that if it were possible to construct two roads side by side using two different grade lines, that a person driving over the road would say that the grade line which required 600 yd. less excavation was just as satisfactory as the more expensive type.

It is not practical, of course, to make the regular plans on as nearly a natural scale as this experiment was conducted. It is, however, perfectly feasible to plot the profile a second time, using this natural scale and replot the grade line after it had been established and quantities computed.

Granting that there might not be any saving in time of the computations of quantities in computing the grade line, it would not take more than two man-hours' extra work to use the two scales than it would the one, and there would certainly be a big saving in the amount of excavation. There are some roads which are to all intents and purposes practically flat and the governing conditions are such that the road must be built above the adjoining field; in this case it is doubtful if any appreciable saving could be effected by this method.

This is not put forward as the last word in establishing grade lines and computing quantities, but rather as a suggestion of what we can accomplish by this method.

Rodney L. Bell,
Division Engineer,
State Highway Department.
Paris, Ill.

UTAH CONTRACTORS ORGANIZE.

To the Editor: Your editorial, "Contractors, Awake!", in the Feb. 21 issue of Engineering and Contracting certainly should wake up the contractors, not only of this section, but of the entire United States. The writer might add that a most enthusiastic organization of contractors of Salt Lake are very happy and pleased to know that each of the contractors of this region will receive a copy of the same, as we feel that an editorial from your hand, with the experience you have, will be of untold value to the realization of a permanent contractors' association in Utah.

Twenty-five of the most prominent contractors met at a dinner the other evening and elected a committee of seven, called an organization committee, whose duties it is to effect an organization, and the writer has been instructed to call a meeting to be held at Ogden, Utah, of all the contractors of Utah and Idaho, who will ratify the rules and by-laws this organization committee will present and elect officers to assume charge and direct the affairs of the permanent association, which, I will take the liberty of saying, will be a live one after it is started.

We most certainly thank you for the interest you have given this matter.

E. W. Ryberg.
Salt Lake City, Utah.

UNIVERSAL MILITARY SERVICE AND COST DATA.

To the Editor: I have read with a great deal of interest your editorial in recent issue of Engineering and Contracting, entitled "Could Not the Question of Universal Military Service Be Answered by Cost Data?" I am pleased to note that you remark simply that no such cost data as you indicate "have ever been published," for it is a fact that such calculations have been made, but the most of them have never been published, or have been published only in fragmentary form.

I agree with you that the method of providing the best protection at the least cost is an economic problem quite similar in many of its aspects to problems of engineering economics. You make the statement that such a calculation should give "all the costs that enter the problem." I appreciate the fact that you do not pretend to discuss all these items in your editorial, but I wish to utter the caution that, unless they are all included, the resulting figures are very apt to be misleading.

I am strongly in favor of a large navy as a first line of defense, but I believe that we would still need universal service. In your figures on the cost of a large navy you have the following annual fixed charge:

On the plant:
Repairs, 1 per cent.
Depreciation, 6 per cent
Interest, 4 per cent.

You state that these figures are approximately correct. I think a further study of the subject would convince you that the annual depreciation of a navy is greater than 6 per cent. The greatest depreciation in the value of a navy as a fighting machine is not that resulting from the physical depreciation of the vessels themselves, but more particularly it is due to the vessels becoming obsolete before they have actually depreciated in a physical sense. Thus, for instance, when ironclad vessels first came into use they rendered all wooden vessels virtually obsolete as fighting machines, even though these vessels might have been maintained in good physical condition and although they may have been just as high in fighting efficiency as ever.

When England created her fleet of dreadnaughts she practically rendered all lesser types of battle craft obsolete. Although the fighting efficiency of these lesser craft remained absolutely the same, their relative fighting value, judged by the new standards, depreciated at a rate far greater than 6 per cent per annum. On the other hand, when a soldier has once been trained by means of a compulsory military service he does not become obsolete until his physical efficiency has, by reason of age, usually, dropped below the military standard. In this respect he has an advantage over a ship, which may become obsolete long before it is actually worn out. Of course, it will be necessary to train our reserves to keep them abreast of developments in the science of warfare, but the cost of so doing is relatively less than that of entirely replacing obsolete naval types.

A soldier who received a thorough regular training 20 years ago would still be a valuable military asset, and with comparatively little additional training could be adapted to the requirements of modern warfare. Of course, vast numbers of such men are now rendering most efficient service on the battlefields of Europe. But, even admitting that your figures are approximately correct, I do not think they demonstrate conclusively that America "would be economically foolish to choose universal military training," although I agree with you that this should not be chosen instead of a large navy. There are other considerations which bear on the problem and which are probably capable of measurement in dollars and cents.

England has been in a particularly favorable situation to adopt a large navy as a means of defense in lieu of compulsory military service. Yet there is some reason to believe that England regrets that she did not also have a good military system prior to the outbreak of the present war. Had England possessed such a system it is quite conceivable that she might have been spared the present war altogether, or had she been able at the outset to oppose Germany as France did it is conceivable that the war might have been over by this time, with victory to England's credit and with a saving of much of the money and life she has spent and will spend in this conflict.

It is not always possible to foresee just what course a war will take. When General Wood was asked to state against what nation or nations he desired to defend America he replied by asking his interlocutor in effect: "What storm the captain of a ship prepared against when he put to sea?" When the present war is over Canada will possess a large veteran army—possibly 500,000 trained soldiers, with an adequate complement of officers —possibly more than this figure. If we have no adequate military system, as you apparently consider advisable, do you think that a large navy would protect us from invasion by Canada? Do you think that it would prevent the Canadians, for instance, from seizing our iron mines in the Superior region, which are said to furnish about 80 per cent of our total output of iron ore? In case our great navy should be defeated by the combined navies of England, Japan and Germany, for example, would it not be a comforting feeling to know that America was still self-sustaining and still able to put up a determined fight for her existence? Would not a reasonably large navy, coupled with an adequate military system, be a cheaper security for our national existence than a navy so great that no possible combination of foreign powers could defeat it? Such a navy would, I feel sure, be very much more expensive than is indicated by your figures.

But entirely aside from the question of national defense there are many intelligent persons who believe that universal military training has an economic value, and some of them would undoubtedly take exception to your statement that "the annual loss of income while in military duty becomes the true criterion of the value assignable to their services." I have talked with a large number of successful men in civil life who had received some military training in their youth. They have all, without a single exception, assured me that they believed such training had been useful to them in their civil careers. The training of most of these men had not been regular nor equal to that which all would receive under the universal system. The young man who spends four years in college is earning nothing during that period, but, on the contrary, requires a continuous outlay for his maintenance during these unproductive years. Yet I think you will not claim that the wealth, happiness and culture of the nation would be greater had all these young men been put to work instead of being sent to college. To this you may answer that the training at college was designed to fit them for their future careers, which military training is not designed to do, but again I would take issue with this view.

I do not believe that Germany's industrial efficiency has been lowered by reason of her system of military education. On the contrary, I believe, with many others, that Germany's industrial efficiency has been increased by her military system, and I know that the Germans themselves are very firm in this belief. Military training, if intelligently applied, will increase a man's industrial efficiency and his general usefulness as a citizen far more than enough to compensate for the time spent in such training.

It would be interesting to learn the value that the Germans put upon their military system from a purely industrial point of view. I feel sure that this is an important element of the problem, and one that should not be omitted from such a calculation as you suggest. This training, of course, would not be limited to purely military matters, but would be also, to a certain extent, scholastic and industrial. But the most valuable part of the training, from the point of view of its effect upon our citizenship, would be the spirit of discipline impressed upon the young men in their early years.

Correct military training inculcates in a man the spirit of honor and truthfulness, promotes personal cleanliness, physical health, respect for constituted authority, alertness of mind and body, and an appreciation of the value of co-ordinate effort. These qualities, and many others which I claim can and should be impressed by a proper system of military training, make for success in civil affairs as well as military. Health statisticians claim that we suffer an actual loss of hundreds of millions of dollars a year in physical degeneracy and death due to preventable causes.

Students of military affairs believe that about 50 per cent of our young men are physically unfit for military service. The most immediate and striking effect of military training is an improvement in the physique. This is, of course, one of the chief objects of the training, for a soldier must first of all be physically sound and fit. Military training improves a man's physical condition and the hygiene and eugenics which form a part of this training teach him how to preserve his physical vigor. This certainly increases his industrial efficiency in after life and, what is perhaps more important, it gives him more joy in living. I do not know that enjoyment of life has ever been measured in dollars and cents, but I am sure that it has a high money value, as witness the fact that most of us are willing to pay more for the luxuries of life than for the necessaries. I am convinced that there is no one other thing we could do that would so greatly improve the average quality of our citizenship, moral, intellectual and physical, as the adoption of a correct system of universal training—not universal training for war alone—but training also for good citizenship—for the good soldier is always a good citizen.

P. S. Bond,
Major, Corps of Engineers, U. S. Army.
Cleveland, O.

Quantities of Stone Required Per Mile of Road.—The following table taken from the recently issued Third Biennial Report of the Wisconsin Highway Commission shows the number of cubic yards of material required per mile to make a given loose depth for various widths of road:

Depth of loose material in inches	Width of surfacing				
	9 ft	14 ft	15 ft	16 ft	18 ft
	Cu.yd.	Cu.yd.	Cu.yd.	Cu.yd.	Cu.yd.
1¼ in (screenings)	183	285	306	326	367
3 in	440	684	733	782	880
4 in	587	913	978	1,043	1,173
5 in	734	1,141	1,222	1,304	1,468
6 in	880	1,369	1,466	1,565	1,760
Square yards of surface per mile	5,280	8,213	8,800	9,387	10,560

EXTRACTS FROM LETTERS SHOWING WHAT THE SUBSCRIBERS THINK OF THE ROTATED SPECIAL MONTHLY ISSUE FEATURE OF E. & C.

We unhesitatingly agree with your new method of editing and publishing E. & C. It is a simple matter to look up some article of previous date pertaining to subject desired. We have found it to be most convenient, as well as being a time saver.

Oregon Gravel & Contracting Co.,
Independence, Ore. N. Wither, Manager.

I believe that much time is saved by your readers by your new arrangement. I find myself looking forward to the copy specializing on excavation with more interest than I ever felt for your general magazine.

W. W. Boone,
Cleveland, Miss. Drainage Engineer.

I think your new method of publication is an excellent one, for, like all engineering data, they are far more valuable segregated, as you have done, than appearing in piece work, as formerly. I sincerely hope you continue with your new method.

W. P. Marshall.
Sacramento, Cal.

Your new method of editing and publishing E. & C. was a welcome change to me. It keeps the mind concentrated on a particular branch of engineering while reading an issue. Very often in my practice I refer to some article published in E. & C. and find it much more convenient for reference under the new method. I consider it a marked advance in the publishing of engineering periodicals.

Frank Schwalbach.
Grand Junction, Colo.

We think the present method of publishing Engineering and Contracting is excellent in that certain issues are bound to contain information that certain groups of engineers are interested in. We read all the copies, however, whenever time is available, as we believe the information contained therein is good.

Division of Water,
Dayton, O. H. C. Wight, Superintendent.

I may say that your new plan is a great advance in the method of editing engineering periodicals. It helps greatly our classification of subjects.

A. Langlois,
Assistant Engineer, Department of Public Works of Canada.
Ottawa, Ont.

I like very much the change you have made in the get-up of the magazine, as it makes it much more convenient to find the articles that are the most interesting and important. In this day of specialization in different lines of engineering work it is only logical that an engineering magazine should be developed along the same lines.

City Hall, Cuyahoga Falls, O. E. D. Barstow.

Your four monthly issues seem to me to be a very good idea. Anything which will do away with three-quarters of the work and time in looking up special articles on data is surely worth while.

W. J. Hodson,
Escanaba, Mich. City Engineer.

Your plan of grouping engineering articles pertaining to one special line of engineering and have these appear monthly has given your paper, in our opinion, a distinctive and valuable feature. For illustration, we are too busy in our own line of engineering work of hydraulic and sanitary work to care to wade through much of the engineering information on other subjects, and our present plan is to note at a glance the entire publication, but lay aside for complete study the monthly containing the articles on our special line of engineering work. We feel that the plan that you have adopted cannot help but prove successful and more valuable to readers.

Burns & McDonnell,
Kansas City, Mo. Consulting Engineers.

We believe the scheme is a long stride in advance of the times and a radical departure towards classification or indexing special subjects; in fact, an orderly plan or index that will be appreciated as the engineer or contractor becomes accustomed to the idea. The paper comes in the form we like from every point of view.

Geo. W. Simons,
Dayton, O. Manager, Pacific Bridge Co.

Your rotated monthly special issues with grouped articles is an important improvement, making the information readily accessible, and I hope the change is permanent.

J. J. Smith,
Grand Forks, N. Dak. City Engineer.

I like your new method of editing and publishing Engineering and Contracting. The plan of so grouping the articles as to produce four rotated monthly issues I find more convenient in referring to artcles on a given subject.

Frank P. Damon,
Tallahassee, Fla. Engineer Florida Commission.

I think your present arrangement of Engineering and Contracting is very satisfactory, particularly from the point of view of the engineer who, as is the case with the majority, is working in one of the groups represented by one of your divisions.

Charles Rufus Harte,
Construction Engineer, The Connecticut Co.
New Haven, Conn.

I greatly appreciate the plan of grouping your articles so as to give us what I would call a departmental cyclopedia, specially valuable when we have to call on it for references on a given subject. The more you will improve in that direction the better.

J. T. Bertrand,
Isle Verte, Que. District Engineer.

I am very well pleased with the magazine as now published. The new arrangement gives promise of saving considerable time in that the issues may be grouped under their respective heading and the desired subject may be more readily found. It is my hope that you will continue to present E. & C. in its present form.

John N. Eddy,
Billings, Mont. County Surveyor.

EFFECT OF CREOSOTE TREATMENT ON STRENGTH OF LONG-LEAF PINE PAVING BLOCKS.

A series of tests has been made at the U. S. Forest Products Laboratory on creosoted blocks treated under the laboratory bleeding specification to determine the effect of the treatment on strength. Four runs were made on air-dry sap, air-dry heart, green sap and green heart of long-leaf pine paving blocks. The specification recommended by the U. S. Forest Service was followed throughout, the upper limits of the specification in each case being used. The blocks were removed from the cylinder at the end of the vacuum period and before applying oil under pressure, and were weighed in order to determine the amount of moisture absorbed or lost during the steaming and vacuum periods. It was found that the air-dry blocks, both sap and heart, gained in moisture during treatment, while the green blocks, both sap and heartwood, lost in moisture. Upon removal from the cylinder after treatment the blocks were very clean and dry and could be readily handled without soiling the fingers. Remarkably good penetrations were obtained and the blocks were found to be satisfactorily treated. After treatment they were turned over to the section of timber tests for running strength tests; and, making the proper allowance for moisture content and other factors, the tests showed conclusively that the strength of the blocks had not been reduced by the treatment.

METHOD OF MAINTAINING STATE AID ROADS IN ILLINOIS.

Contributed by B. H. Piepmeier, Maintenance Engineer, Illinois State Highway Department.

The "State Aid" law of Illinois, which became effective July 1, 1913, provides for the construction of a system of State aid roads at the joint expense of the State and the counties. The system of routes as planned comprises 16,000 miles or about 17 per cent of the road mileage of the State.

When a road has been constructed as a State aid road in accordance with this law, the chief state highway engineer or his authorized assistants are required to keep it in proper repair. If the road is constructed of concrete, brick or the equivalent, the State pays the entire maintenance cost; if constructed of gravel, macadam or similar types, the State and county each pay one-half of the maintenance cost; and if earth or oiled earth roads are built, the county pays the entire cost of maintenance.

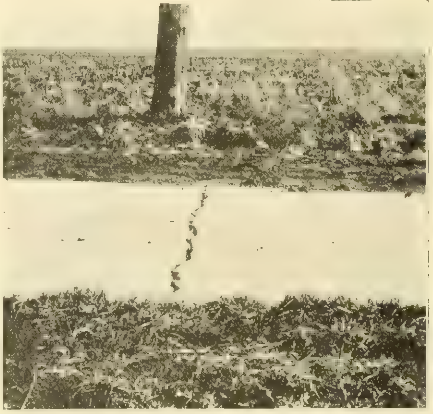


Fig. 1—Large Crack in Concrete Pavement in Serious Need of Repair.

The law further stipulates that the county boards of the various counties in the State shall select the site and type of all State aid improvement in their respective counties.

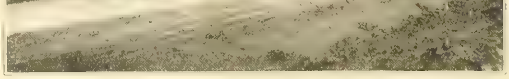


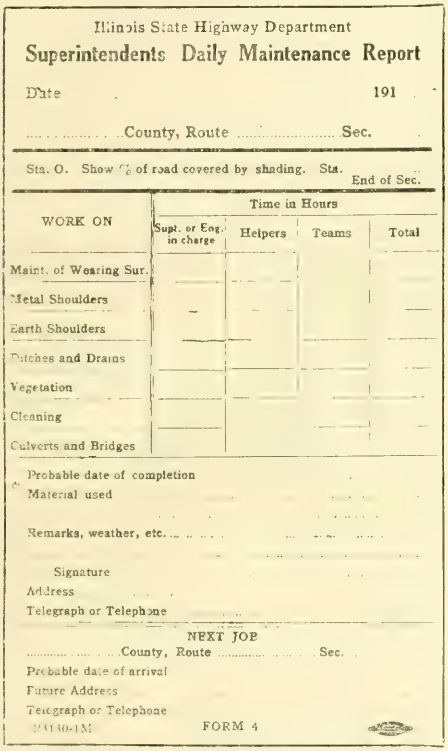
Fig. 2—Repair Outfit at Work on Concrete Pavement Filling Cracks and Joints With Bituminous Material and Torpedo Gravel.

Since the enactment of the law in 1913 there have been constructed and accepted to Jan. 1, 1917, the following roads:

	Miles.
Concrete	142.76
Brick	47.07
Gravel and macadam	8.10
Bituminous roads	6.18
Earth roads	14.51
All other types	6.30
Total	224.92

It is readily seen that where the selection of the type and site of the comparatively small mileage of improved roads is left in the hands of 102 different county organizations of the State that there would be a very wide variation of types and further a disconnected system of State improvements.

The average length of the various sections of State aid roads that make up the total mileage listed above is less than one mile. When any one county has several miles of State aid road they are usually split up in small sections and located in the various parts of the county. It is evident, therefore, from the conditions cited that the construction as well as the maintenance of State aid roads has been difficult and expensive.



Illinois State Highway Department

Superintendents Daily Maintenance Report

Date 191

County, Route Sec.

Sta. O. Show % of road covered by shading. Sta. End of Sec.

WORK ON	Time in Hours			
	Supt. or Eng. in charge	Helpers	Teams	Total
Maint. of Wearing Sur.				
Metal Shoulders				
Earth Shoulders				
Ditches and Drains				
Vegetation				
Cleaning				
Culverts and Bridges				

Probable date of completion
Material used

Remarks, weather, etc.

Signature
Address
Telegraph or Telephone

NEXT JOB
County, Route Sec.
Probable date of arrival
Future Address
Telegraph or Telephone
23130-1M FORM 4

Form 1—Daily Maintenance Report Card, Which Is Mailed Direct to Division Engineer's Office.

One of the greatest problems connected with the maintenance of the various isolated sections of State roads was that of organization or field forces that would enable the work to be handled promptly and economically.

The organization that has been perfected under W. W. Marr, Chief State Highway Engineer, is as follows:

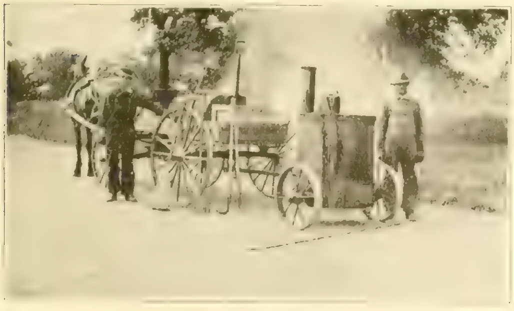
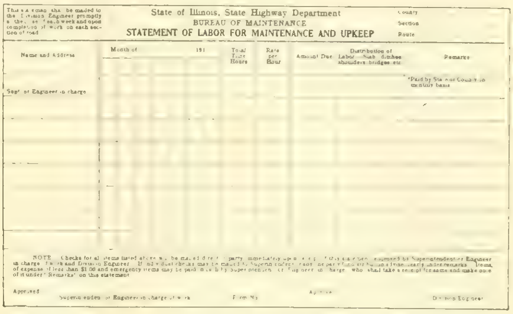


Fig. 3—Auto Maintenance Truck With Complete Maintenance Euipment for Filling Cracks and Joints in Concrete Pavements.

All maintenance work is handled by the Bureau of Maintenance under the general direction of the maintenance engineer. The field work is under the direct supervision of the seven division engineers who have jurisdiction over all construction and maintenance in their respective divisions. The actual maintenance work of a gang is under a superintendent who reports direct to the division engineer.

In view of the isolated position of many of the State aid roads it has been necessary to follow primarily the gang system in maintaining.



State of Illinois, State Highway Department
BUREAU OF MAINTENANCE
STATEMENT OF LABOR FOR MAINTENANCE AND UPKEEP

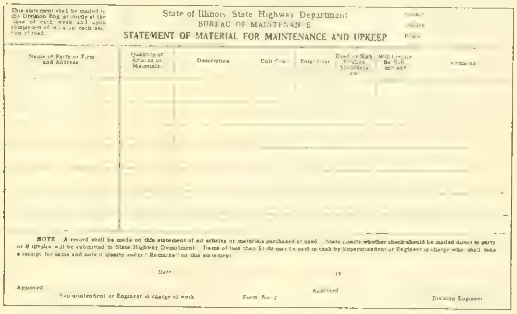
County
Section
Route

Name and Address	Month of 191	Total Time Hours	Rate per Hour	Amount Due	Distribution of Labor Slab ditches shoulders bridges etc	Remarks
Supt. or Engineer in charge						*Paid by State or County on monthly basis

Approved
Superintendent or Engineer in charge of work
Division Engineer

Form 2—Labor Record Used by Superintendent in Charge of Maintenance Work. All payments for labor are made from these reports. Actual size of blank, 5x7½ in.

The superintendent in charge of the gang is equipped with a small Ford truck, 50-gal. heating kettle, steel wire broom, heavy fiber broom, steel hook, pouring pot, shovel, pick and incidental tools. The heating kettle is mounted on the rear of the truck when in transit from one section to another. The necessary bituminous material is shipped to the various stations in advance of the maintenance gang so that the maximum load the truck is required to haul is about 900 lb.



State of Illinois State Highway Department
BUREAU OF MAINTENANCE
STATEMENT OF MATERIAL FOR MAINTENANCE AND UPKEEP

Name of Party or Firm and Address	Quantity of Articles or Materials	Description	Unit Cost	Total Cost	Used on Slab Ditches Shoulders etc	Will Invoice Be Submitted?	Remarks

NOTE A record shall be made on this statement of all articles or materials purchased or used. State clearly whether check should be mailed direct to party or if invoice will be submitted to State Highway Department. Items of less than $1.00 may be paid in cash by Superintendent or Engineer in charge who shall take a receipt for same and note it clearly under "Remarks" on this statement.

Date 19

Approved
Superintendent or Engineer in charge of work
Approved
Division Engineer

Form 3—Material Record Used by Superintendent in Charge of Maintenance Work. All payments for material are made from these reports or from itemized invoices, properly approved. Actual size of blank, 5x7½ in.

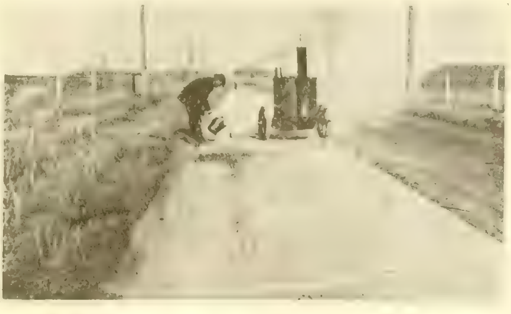


Fig. 4—Maintenance Crew Filling Cracks and Joints in Concrete Pavements.

The small Ford truck has proven to be a very satisfactory and efficient means of getting the maintenance gang from one section to another. The maintenance crew consists of one superintendent and usually a helper. The additional help is secured after arriving on the various jobs. The State now has five small trucks and five portable heating kettles in maintenance service. The portable heating kettles are shipped from place to place particularly in the case of extreme isolated sections where it is not convenient or economical for the truck to reach.

The superintendent in charge of a maintenance gang is required to make a daily report to his division engineer on a specially prepared and addressed postal card as shown in Form 1. The superintendent is further required to make out a statement as shown in Form 2, showing the amount of work done at the end of each week or upon the completion of a definite section of maintenance work. The statement shall show the proper distribution of his time and all helpers. He shall make similar statement as shown in Form 3 for all materials used. Both forms shall be complete in all details and clearly indicate the distribution of expenditures for maintaining the traveled portions of the road, the side roads, ditches, culverts, etc. The two statements are signed by the superintendent and immediately forwarded to the division office, where the statements are approved and then forwarded to the Bureau of Maintenance.

Immediately upon the receipt of all approved labor statements or invoices for materials at the Bureau of Maintenance, the maintenance engineer directs their payment. All items of less than $50 are usually paid by check from a special maintenance fund set aside for checking purposes. All items of expense that can be conveniently delayed three weeks or more and all items exceeding $50 are paid by voucher through the State Auditor upon approval of the Chief State Highway Engineer and State Highway Commission.

All checks issued are made as voucher checks and show the county, section and the itemized labor or material covered by the amount of the check. The checks are mailed direct to the parties furnishing the labor or materials and the canceled checks are turned back to the State Auditor for credit on the special checking account.

All vouchers issued on the State Auditor are recorded in a voucher journal from which is made up the journal that shows all items of expense distributed to the proper county and section of road. The general distribution is made by aid of field reports. From the journal all items of expense are entered in a ledger under the proper section of road or item of maintenance expense. From this ledger all items of expense are distributed in detail in the distribution ledger, which is merely for the purpose of showing the total cost of maintenance on the traveled portion of the improved road and the total expense of upkeep on the side roads, ditches, weeds, culverts, etc. The distribution ledger further shows the amount of labor materials, equipment, supervision, etc., required in the maintenance and upkeep of any particular section of road.

The two fundamental divisions of expense are the expenditure required on the traveled portion of the pavement and the total expense on the remainder of the road. The upkeep cost on side roads, ditches, culverts, etc., remains practically constant for all types of improvements, while the maintenance of the traveled portion of the improvement is variable.

Average Unit Costs of State Aid Road Work in Wisconsin.—The recently issued Third Biennial Report of the Wisconsin Highway Commission gives the following figures regarding the cost of the various units of state aid work in 1914 and 1915:

	Max.	Min.	Av.
Cubic yard excavation, 1914	$0.57	$0.17	$0.35
Cubic yard excavation, 1915	0.54	0.18	0.34
Cubic yard of concrete in culverts, 1914	15.20	5.55	8.43
Cubic yard of concrete in culverts, 1915	11.05	5.44	8.08
Square yard of waterbound stone macadam, 1914	0.89	0.30	0.54
Square yard of waterbound stone macadam, 1915	0.89	0.30	0.53
Square yard of crushed gravel macadam, 1914	0.86	0.19	0.35
Square yard of crushed gravel macadam, 1915	0.61	0.21	0.28
Square yard of concrete pavement, 1914	2.15	1.05	1.25
Square yard of concrete pavement, 1915	1.49	1.02	1.17
Linear foot of guard rail, 1914	0.36	0.08	0.18
Linear foot of guard rail, 1915	0.31	0.08	0.20
County aid bridges, per foot of length, 1914	70.00	21.40	39.69
County aid bridges, per foot of length, 1915	95.70	25.00	40.64
State aid bridges, per foot of length, 1914	114.80	25.10	42.88
State aid bridges, per foot of length, 1915	82.10	25.10	37.95

TRAFFIC ANALYSIS AND CENSUS PROCEDURES.

A noteworthy discussion on highway traffic analysis and census procedure was presented on Dec. 28 before Section D of the American Association for the Advancement of Science by Mr. William H. Connell, Chief, Bureau of Highways and Street Cleaning of Philadelphia. In his paper, which is given in abstract below, Mr. Connell brought out many interesting points regarding the classification of traffic and described in some detail the methods employed by his bureau.

Traffic planning is a problem in itself. Its purposes should be to develop closer and more consistent relations between probable traffic requirements and existing and proposed traffic provisions.

The operations constituting the general function of traffic study may be properly subdivided into two general classifications, as governed by the purposes and nature of the data to be obtained and of the methods of investigation involved:

Traffic Survey: Which has to do with the investigation of the physical and other conditions influencing or relating to the carrying of proposed or existing highway traffic.

Traffic Census: Which has to do with investigation of the quantity, character, weights and other conditions of traffic.

A system of traffic study to be complete and comprehensive should provide ample data for a full consideration of the following features:

The Plan of the Highway: Including the consideration of the use of curved, rectangular or diagonal lines, and of the necessity and location of traffic circuit highways; the determination of the grade; the number and desirable width of the roadways and footways to accommodate present and probable future traffic requirements; and the possibility of devoting certain spaces to the purposes of temporary or permanent lawn or planting areas.

The Design of the Pavement: Including the advisability of improving the full legal width of the roadway and footways, and the selection of the types of pavement surfaces and base course construction best suited to the requirements of the prevailing traffic.

The Maintenance of the Pavements: Including the study of the depreciation and maintenance costs per unit of traffic and of the physical effects of traffic upon the pavement surfaces with respect to total and unit vehicle loads, width and character of tires, speed, and non-skidding and braking devices.

The Cleaning of Highways: Including the determination of the kind of cleaning best suited to the existing type of pavement and the prevailing character of traffic, and of the hours during which the cleaning may be performed with the least interference or inconvenience to traffic.

Traffic Regulations: Including the assignment of definite highways for specific classes and directions of traffic; the designation of parking areas for automobiles and other vehicles; the establishment of pedestrian crossings and safety islands and zones; the determination of the most suitable location for proposed street railway tracks and the consideration of the advisability of relocating existing tracks; and the establishment of a general system of control by signal devices or otherwise to insure safety and to eliminate entirely or reduce to a minimum the congestion of both vehicular and pedestrian traffic.

Traffic Units.

No standard methods have been universally adopted for the classification of traffic; for the taking of traffic census data; or for the reduction of the census data to definite units. While most traffic censuses are conducted along the same general principles, yet the absence of a uniformity of details, and especially of a generally recognized standard traffic unit, has confined the value of most traffic data largely to the purposes of local comparison. The character of the data should, nevertheless, be such as to permit them, in addition to being used for local comparative purposes, being also studied in connection with data taken in similar situations in other localities.

In most traffic censuses conducted thus far it has been the general practice to consider as a proper traffic unit the value expressed by the term "ton of traffic per foot width of pavement," which is based upon the total load passing over the entire width of the pavement in a measured period of time. This is misleading and practically worthless as a factor to be used in connection with the designing of a suitable type of pavement, due to the fact that in most cases only a relatively small portion of the width of a roadway carries the maximum traffic load, while the remainder carries comparatively little traffic.

A pavement to be used in any specific situation must, of course, be practically of a uniform character of material, and this makes it all the more necessary that the selected type of pavement be capable of performing satisfactory service at the point of maximum wear which necessarily lies within the maximum traveled width of the pavement, and especially in the tire paths.

The segregation of moving traffic is due to several causes, principal among which may be included the parking of vehicles along the curbs or in the center of highways, and the presence or absence of railway tracks.

It is obvious, therefore, that the maximum traveled width or that width of roadway subjected to moving traffic rarely equals the total width of the roadway. In each case, however, the approximate traveled width should be carefully investigated. In most cases it will be found to vary only between one and two times the average width of the prevailing type of vehicle, and in many other cases between one and several times the average width of each of the tire paths. The logical necessity for the consideration of the "maximum traveled width" in preference to the "entire width" of a roadway will be fully justified when it is considered that the unit "average tonnage per foot width of roadway" will give values far less than those given by the unit "average tonnage per foot of maximum traveled width of roadway."

For the purpose of the selection of a satisfactory type of roadway pavement for any given situation it is also very necessary that the annual maintenance and the life cost (depreciation and interest on first cost) of the type of pavement under consideration per unit of traffic be known with some degree of certainty.

The most logical and satisfactory unit of traffic measurement yet proposed would seem to be the "ton mile" or its multiples, such as "hundred-ton mile" or "thousand-ton-mile." To obtain the actual ton mile of traffic the census figures that represent the maximum load should be reduced proportionately to give the average load.

The use of the "ton mile" unit will not alter or render more difficult the general methods employed in the taking of traffic census data. It is only necessary that the observer be stationed in a block or stretch of highway of known length where every vehicle in passing the observation point must actually traverse a definite fractional part of a mile length of highway.

For the purpose of local comparison it is seldom necessary to use more than one kind of traffic unit, but when it is desirable to provide data that may be compared with studies made in similar situations in other communities any additional kinds of units that may be necessary should be used in order that the data may be reduced to comparable form.

Classification of Traffic.

As governed by the weights of vehicles and the characters of their tires, vehicular traffic should be divided into as many classifications as may be necessary to give fairly accurate results. In general, however, 14 somewhat standard classifications have been proposed, which while more or less arbitrary in determination are nevertheless considered to be fairly representative of average traffic values. These several classifications are as follows:

Classification.	Character of traffic.	Average weight in short tons.
Horse-drawn.		
(a)	Horse without vehicle	.65
(b)	Light one-horse-drawn vehicle	1.20
(c)	Heavy one-horse-drawn vehicle	2.00
(d)	Light two-horse drawn vehicle	2.00
(e)	Heavy two horse drawn vehicle	4.00
(f)	Three-horse-drawn vehicle	5.00
(g)	Four-horse-drawn vehicle	6.00
Motor-driven		
(h)	Motorcycle or bicycle	.15
(i)	Two-passenger motor vehicle	1.30
(j)	Over two-passenger motor vehicle	2.20
(k)	Light freight motor truck	3.30
(l)	Medium freight motor truck	6.00
(m)	Heavy freight motor truck	8.50
Miscellaneous.		
(n)	Miscellaneous extra heavy traffic	As individually estimated

The terms "light," "medium" and "heavy" as used in these traffic classifications are intended to indicate the maximum possible capacity of the vehicle and not the relative weight value of the load carried at the time of its observation. These classifications of traffic are only intended to serve for general purposes.

In determining the probable compressive, shearing and impact stresses produced in the pavement it will be necessary also to determine the maximum unit weights carried per inch effective width of tire. In this connection it should be noted that the several characters of tires in general use include both metal and smooth surfaced and non-skidding rubber tires of both the solid type and of the inflated type, and also caterpillar solid rubber tires and tires equipped with non-skidding devices.

Analysis of Traffic Census Data.

The data compiled from a systematic census count taken each year as being representative of the average traffic conditions prevailing throughout the year make it possible to estimate very closely the total probable tonnage carried during the entire year. These data, when considered in conjunction with the records of the total annual charges for depreciation and interest on first cost and maintenance costs and the average traveled widths of the pavements, will give the following analysis:

Traffic tonnage
(a) Total tons of traffic per year carried by the highway.
(b) Average tons of traffic per year per foot width of roadway pavement.
(c) Average tons of traffic per year per foot of maximum traveled width of roadway pavement.
(d) Total tonnage for life of pavement per foot width of roadway.
(e) Total tonnage for life of pavement per foot of maximum traveled width.

Ton-mile maintenance costs:
(f) Annual charges for depreciation and maintenance cost per ton-mile of traffic.
(g) Total charges for depreciation and maintenance cost per ton-mile for life of pavement.
(h) Average ton-mile of traffic per 1 cent of charges for average annual cost of pavement.

These data will show definitely the relations that actually exist between the traffic service and the depreciation and the maintenance costs of the pavements, which constitutes a most important factor to be considered in the selection of a type of pavement.

Traffic Census Procedure.

In all kinds of traffic studies, irrespective of their specific purpose, a definite traffic census procedure is of fundamental importance. This is equally true whether the subject of the study be an existing highway or a proposed highway. Of course, when an existing highway is under consideration, it will be practically always possible to collect traffic census data directly from the specific highway; but in the case of a proposed highway the traffic census data would necessarily have to relate to a selected highway upon which the general conditions would be estimated to be analogous to the conditions that would probably exist on the proposed highway.

The taking of a traffic census and the determination of the probable future traffic is therefore the first step to be considered in connection with a traffic study.

In order to insure accurate results it is important that the traffic census be well planned and that the census-taking force be thoroughly instructed and trained in the requirements of the work.

Location of Observation Points and Frequency of Observation.—Observation points should be carefully selected, and at a sufficient number of points on the highways throughout the city to collectively be considered as representing the characteristic traffic requirements on each general class of highway and on all of the several kinds of modern street and road pavements in general use.

In order to obtain complete representative annual records it is desirable that during each year four separate census counts should be taken at each observation point, one count being made during each of the four seasons of spring, summer, autumn and winter. Each count should be taken continuously between the hours of 5 a. m. and 9 p. m., or during the entire 24 hours if so desired, on a consecutive Friday, Saturday, Sunday and Monday, which days will provide data for two full business days, a half holiday and a whole holiday.

In this connection it is important to note that, while city streets carry maximum traffic on business days, suburban and country roads carry their maximum traffic on Sundays and holidays, and vice versa, which condition is due primarily to the alternate suspension of business traffic in favor of pleasure traffic.

The observers should ordinarily be on duty in two eight-hour shifts, working respectively from 5 a. m. to 1 p. m. and from 1 p. m. to 9 p. m. Under average conditions one observer should be stationed at each observation point, but if, however, the volume of traffic or the number or extent of the details to be noted required two or more observers be assigned it should be arranged, as conditions may necessitate, that each of the two observers will each record exclusively the traffic going in one general direction.

Traffic Observation.—To provide for the systematic collection of traffic data the following forms should be provided:

(a) Traffic conditions survey reports.
(b) Traffic census observation reports; one form for each of the several observation periods.
(c) Traffic census observation report summary forms.
(d) Traffic census data compilation reports.

For each location at which observations are to be made there should also be made a traffic conditions survey and the resulting data noted on the report. These data should include the following information:

(a) Name and limits of highway.
(b) Serial number and location of observation point.
(c) Length of highway dominated by observation point.
(d) Number, location and widths of paved and unpaved roadways and footways.
(e) Character of roadway pavement surface and base, and of footway pavement surfaces.
(f) Traveled widths of roadway and footway pavements.
(g) Presence or absence and number and location of railway tracks.
(h) Direction of railway traffic.
(i) Number, width and general location of vehicle parking areas.
(j) Number, location, width and character of any lawn or planting areas.
(k) General direction of vehicular traffic.
(l) Date of observation.
(m) Names of observers.

During the census-taking operations each observer should indicate on the traffic census observation report the following data:

Fixed conditions:
  (a) Name and limits of highway.
  (b) Serial number and location of observation point.
  (c) General condition of pavement as regards repair.
Variable conditions:
  (d) Date of observation.
  (e) Observation period.
  (f) Number and names of observers.
  (g) Weather conditions.
  (h) General condition of pavement as regard its state of cleanliness, dryness and slipperiness.
Traffic conditions:
  (i) Number of units of each class of traffic passing the point of observation during each clock hour.
  (j) Number of complete or partial falls of horses and skidding of motor vehicles.
  (k) Total number of units under items (i) and (j) for each clock hour and for the entire observation period.

The data required under "Traffic Conditions" should be recorded currently for each clock hour of the observation period.

In certain investigations made in conjunction with traffic regulation or planning studies it may, however, be necessary to observe also the quantity of pedestrian traffic on the footways and at the crossings, or to obtain certain other special data and in situations of this kind it will be necessary to devise special forms on which to collect and compile this information.

The observation reports for each day should be mailed at the close of the observer's period of duty to the main office, where they should be summarized on the traffic census observation report summary, which is simply a compilation of the data contained in the several observation reports for the entire four days' observations at a specific observation point.

Compilation of Traffic Census Data.—For each length of highway on which a traffic census is taken a traffic census data compilation report should be originated, to serve as a permanent and complete record of all the census data that may be collected from within the limits indicated. On this report there should be recorded from the observation report and summary forms the following data:

Fixed conditions:
  (a) Name and limits of highway.
  (b) Serial number and location of observation point.
Variable conditions:
  (c) Date of observation.
  (d) Character of traffic day.
  (e) Weather conditions.
Traffic (vehicle) data:
  (f) Total horse-drawn, motor-driven, and total traffic per day.
  (g) Average horse-drawn, motor-driven, and total traffic per day.
  (h) Maximum hour; quantity and clock hour designated.
  (i) Average per minute per foot width of paved roadway.
  (j) Average per minute per foot of maximum traveled width of roadway pavement.
Traffic (tonnage) data:
  (k) Horse-drawn, motor-driven, and total traffic per hour.
  (l) Horse-drawn, motor-driven, and total traffic per day.
  (m) Average per minute per foot width of paved roadway.
  (n) Average per minute per foot of maximum traveled width of paved roadway.
  (o) Percentages of horse-drawn and motor-driven traffic.

THE EARLIER BRICK PAVEMENTS OF CLEVELAND, O.

In the paper, "The Latest Development in Brick Pavement Construction," presented on Feb. 8 at the annual convention of the American Road Builders' Association, Mr. Fred R. Williams, Engineer of Paving of the city of Cleveland, O., describes briefly the earlier brick pavements of the city of Cleveland and Cuyahoga County. This portion of his remarks follows:

The first brick pavement in the city of Cleveland was laid in 1887 on E. 65th St., between Euclid Ave. and Curtiss Ave. This pavement is recorded as built of fire brick laid on a natural foundation. No record was made of the kind of filler used. A couple of years later a section of Linwood Ave. was paved with a small, plain wire-cut brick with tar filler. This also was laid on a natural foundation.

From 1887 up to about 1900 many plain wire-cut brick tar filled pavements were laid in the city of Cleveland. While the brick in these pavements are all rounded, the general surface is fairly uniform and many of the streets are still in a usable condition.

About 1898 the standard 5-in. block came into use in the city of Cleveland. These were laid on a natural sand foundation, using cement grout filler. The type is still in use in certain residential sections of Cleveland.

The gradual change in types of construction of brick pavement occurred in the county in the same order as that in the city, but started at a later date.

The first brick road in Cuyahoga County was that laid on Wooster Pike during the years 1893 to 1895. This pavement, 8 ft. in width, was laid on a 6-in. broken stone foundation, using tar for filler. No adequate drainage was provided and depressions soon developed. It remained in service, however, for nearly 20 years, when it was replaced with a brick pavement 30 ft. wide.

About 1895, State Road was built with 4-in. brick for a wearing surface and 4-in. concrete for foundation. Cement grout was used as the filler in this road.

The first pavement in Cleveland laid on a concrete base was that laid in 1898 on Lexington Ave. This pavement consisted of a 5-in. standard size block laid on a 6-in. concrete base with a 2-in. sand cushion. Several years later double car tracks were laid in this street, thus renewing the central 15 ft. of the roadway. That part of the original pavement remaining is in a fairly good condition today.

The use of concrete as a foundation has increased since that date and at the present time the majority of pavements laid have a concrete base specified. Until 1915 the sand cushion was used between the brick and base. During that year both city and county started to use the cement-sand cushion type, and following that the green concrete foundation type. Four-inch brick have been used by the city in the green concrete foundation type, while the county have used both 4-in. and 3-in. brick, depending upon the traffic to be served. Since 1900, with few exceptions, cement grout has been used both by the city and county as the joint filler.

NEW METHODS AND DEVICES FOR CONCRETE PAVEMENT CONSTRUCTION.

Much progress has been made in the past two years in the development of new ideas, methods and devices for the construction of concrete pavements. An interesting outline of the recent advances in these lines were given by Mr. W. M. Kinney, Engineer, Universal Portland Cement Co. in a paper presented Feb. 10 before the American Concrete Institute, from which the notes that follow are taken.

On jobs where materials are placed on the subgrade much trouble can be saved and considerable economy effected by dumping them systematically along the work so that there will be a minimum trip for the wheelbarrows, and at the same time no overages which must be hauled back or used in the shoulders. To the storage of cement the same applies. A uniform supply of cement at measured intervals along the road gives an accurate and easy check on the amount used. Such storage units are also always ready to withstand a sudden rainstorm, thus permitting the use of all men available to get the unfinished concrete under cover.

When a sudden rainstorm comes up the wise contractor will be provided against this emergency by having ready for use a canvas cover and preferably some type of framework on which to support it. This prevents the pitting of the surface by rainfall and the framework avoids unsightly marks on the pavement surface which would be caused by placing the canvas directly on the concrete. Such frames if made of light material can be moved along as the work progresses and will be useful in preventing too rapid drying out of the surface immediately after it is finished. On one job where considerable rain was experienced, the frame was so constructed and the canvas of such width that the workmen could finish under the canvas during even a protracted rain.

We are not sure of the cause of certain defects that appear in concrete roads and pavements, but it is certain that the use of an excess of water is responsible for by far the greatest number. Laboratory experiments have demonstrated that the strength of concrete is greatly reduced by the addition of water beyond that necessary to make a workable mix; in fact it is stated on good authority that changes in amount of water have as great an influence on the strength as changes in amount of cement. This suggests, then, the probability that future supecifications will state not only the proportions of cement and aggregates to be used, but the amount of water. Automatic devices for measuring or weighing the amount of water for each batch are already in common use.

Closely associated with the amount of water used and quite as important in its effect on strength is the time of mixing. Proper mixing of the ingredients of concrete cannot be effected in less than one minute, and a longer time will usually be found well worth the extra expense. The time of mixing also has an important influence on the amount of water used, as it is possible with continued mixing to increase the plasticity with less segregation of coarse aggregate from the mortar.

Several devices are on the market with which it is possible to insure a minute mix. One of the simplest is an egg timer of the hour glass type from which enough sand is taken so that the balance will run through in a minute's time. This can be hung at a conspicuous place on the mixer and is reversed as each charge is made, and can be seen by the inspector from a considerable distance. Other styles depend for their operation on time or number of revolutions. One type makes it impossible to discharge the concrete until the full period has elapsed.

Probably no new method used in constructing roads has attracted more interest among engineers and contractors than the use of belts for finishing. Wherever the belt was given a thorough trial the tedious process of finishing with hand floats from a cumbersome bridge has been supplanted. A surface more free from irregularities is obtained at a considerable saving in cost.

Being a new method, standard practice in the use of belts for finishing has not yet been established, but general use indicates a preference for three to four-ply belts, 8 to 10 in. wide. The 8-in. belt is used immediately after the concrete has been struck off, and the wider belt for final finishing. This final finishing should be done as late as possible and still produce a surface of uniform texture. If final finishing is done too soon hair cracks will result, particularly if a hot, dry wind blows over the concrete. There is also more tendency to draw excess water and cement to the surface, thus producing a pavement which will wear quickly until the coarse aggregate is reached.

Canvas-faced and rubber-faced belts have been tried as well as strips of ordinary tarpaulin. Because of its greater pliability, limited experience seems to favor the rubber-faced belt. For the same reason canvas belts which have been in service are to be preferred to new ones.

Some difficulty has been experienced in the use of belts where stone screenings were used for the fine aggregate. Spots will frequently be left in the surface which must be hand floated in order to give the proper wearing surface. The belt will probably be found advantageous in all forms of road construction, but its first use should be watched carefully to make sure that an absolutely uniform texture is obtained.

As the use of a belt produces no appreciable compacting of the surface, a strikeboard with which it is possible to do some tamping of the concrete is recommended. This strikeboard should have a face about 8 in. wide and be provided with long handles similar to those used on a plow, as the strain on workmen using such a strikeboard is too great if they have to bend over to do the work. The use of a tamping strikeboard also permits mixing the concrete to a dryer consistency because the tamping brings more mortar to the surface than the usual see-saw motion of a narrow strike.

Belts are found to be particularly advantageous where the road is constructed without joints, as it is usually necessary where they are employed to finish at the joints with a wooden float and steel trowel.

How to strike and finish concrete on wide streets is a problem which has bothered some contractors and made others hesitate to bid on such work. The construction of a suitable strikeboard and its proper operation at reasonable cost is a difficult problem. During the past year the Illinois Hydraulic Stone & Construction Co. constructed on Sheridan Road, Kenilworth, Ill., a very excellent pavement on which the proper contour was obtained by hand work, using "lutes" or short strikes, and working to stakes set at frequent intervals. This does away with the inconvenience of using a long strikeboard and is particularly advantageous when streets have variable crowns to provide for gutter drainage. The results speak well for this method and suggest the training of finishers for this class of work.

During the past year considerable improvement has been noted in the machines for finishing concrete roads. In Wayne County, Michigan, the Baker machine is being used with considerable success. Successful also is the work being done in Oakland County, Michigan, by the R. D. Baker Co. The old objection to this machine that too wet a mix was required for smooth operation has been overcome and the finishing machine is destined to play a more prominent part in future concrete road construction. Where no joints are used it has particular advantages as extreme care at the joints is usually needed to secure the best results. It is probable that only by employing a machine of this or some other type such as the Cowell finishing machine, used in California, can we have the stiff mix so essential to the best results.

Ultimately we will undoubtedly consider a consistency such as we use now, far too wet for the best results, and will find it impossible to finish concrete of the desired consistency without some preliminary tamping or vibrating by machine. For street work a vibrating machine of the type devised and patented by R. C. Stubbs of Dallas, Tex., may be found advantageous. This machine is operated over a flexible board mat placed on the fresh concrete and should permit the use of a comparatively dry mix, although photographs of work done with the apparatus seem to indicate an excessive amount of mortar on the surface of the work.

For installing unprotected joints the methods used heretofore have not, as a rule, been entirely satisfactory. A plank on edge is usually staked across the pavement, the filler is placed against the plank, and when concrete has been deposited on both sides the plank is withdrawn. This method of procedure is objectionable in that it seriously disturbs the joint, often raising the filler from the subgrade 1 to 3 in., which practically destroys its value. To overcome this difficulty a device has been developed and successfully used on several jobs. It consists of a light steel channel or 2 by 8-in. plank, supported edgewise, on the side rails (by means of small brackets or standards), a sufficient distance above the side rails to allow for the crown in the pavement and for the ½-in. joint filler extending above the pavement surface. To this channel, or plank, are bolted steel fingers extending below its lower edge, a distance equal to the thickness of the pavement, plus the crown and the projection of the filler above the pavement. These fingers are made from ½-in. by ⅜-in. strap iron and are placed 12 to 18 in. on centers. Eccentrics formed of ½-in. round rods are placed opposite each alternate finger in such a manner as to leave an opening somewhat less than the thickness of the filler when the eccentric is closed between it and the steel finger. These eccentrics extend through both flanges of the channel or through the 2 by 8 plank and the upper ends are bent at right angles, forming a handle, by means of which they are adjusted. The joint filler is placed between the eccentric and the steel fingers. The eccentrics are then closed and the device is set in place. When the concrete has been deposited on both sides of the filler the eccentrics are loosened and the device withdrawn, leaving the filler in place undisturbed. The device should be set in place with the side on which the fingers are bolted facing the mixer, so that a backing is provided for the filler until the concrete is placed against it. A filler having considerable rigidity is preferable when using this device.

The curing of concrete pavements is an important matter. Plenty of water should be used and applied as soon as possible after the work is finished. On hot, dry days sprinkling of work placed in the morning can be started in the afternoon, and almost invariably on all work sprinkling can follow on the next day after placing. Curing by "ponding" is becoming popular where conditions will permit such procedure. This method of applying water to concrete roads after they are finished absolutely insures thorough curing and is destined to become more extensively used.

Cost Per Mile of State Aid Roads in Wisconsin.—The following tabulation from the recently issued Third Biennial Report of the Wisconsin Highway Commission shows the general average cost per mile of the various types of road in Wisconsin. Costs given for surfaced roads include the grading, draining, and culverting.

	Per mile
Grading, draining and culverts only	$ 1,300
Waterbound macadam road, 9 ft. wide	4,200
Waterbound macadam road, 16 ft. wide	6,700
Crushed gravel macadam, 9 ft. wide	3,300
Crushed gravel macadam, 16 ft. wide	5,000
*Concrete road, 9 ft. wide	8,000
*Concrete road, 16 ft. wide	13,000
*Concrete road, 18 ft. wide	14,500
*Brick road, 9 ft. wide	11,500
*Brick road, 16 ft. wide	19,000
Brick road, 18 ft. wide	21,000

*4-ft. shoulders on each side add about $1,000 per mile if of gravel, about $1,500 per mile if of crushed stone.

Sub-Grading for Brick Pavements.—In excavating for brick pavement construction in the city of Cleveland, O., contractors are required to grade within 3 in. of the final subgrade, then to construct small earthen dams dividing the roadbed approximately into squares. The street is flooded with water until the subgrade has been properly puddled or settled. The roadbed is then brought to the proper crown and any additional excavation required is made by the use of picks and shovels.

A LOGARITHMIC AGGREGATE CARD AND ITS APPLICATION TO ASPHALTIC PAVING MIXTURES.

Contributed by C. C. Kennedy, First Assistant Engineer, Berkeley, Cal.

The difficulty of determining the suitability of any material or combination of materials for use as an aggregate by an inspection of the tabulated screen tests, is a matter of such common experience as to require no comment. Consequently, the value of a graphical comparison with some predetermined standard grading need not be argued. In the curve for maximum density, as proposed originally by Mr. Fuller, or any of the later modifications, when drawn to natural scale for the full concrete aggregate, that portion for the material passing the 1-in. mesh is so nearly vertical and so compressed that a careful grading in the lower meshes is not possible. In fine aggregates and mixtures requiring high density this is a matter of vital importance.

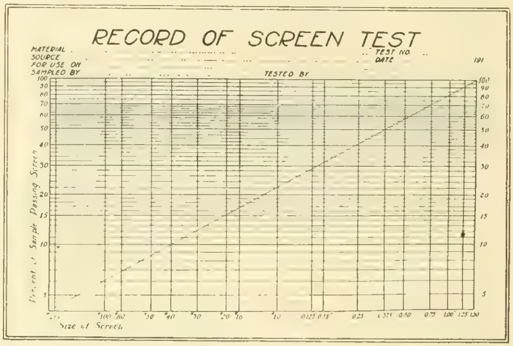


Fig. 1—Logarithmic Aggregate Diagram for Laboratory Work. Actual Size Diagram, 4x6 In.

In an attempt to obtain a diagram from which it would be possible to secure a close grading of the fine portion of the aggregate by combining various grades of materials, the card herein described was worked out in the Engineer's office of the City of Berkeley, Cal. The ideal curve adopted was the original Fuller maximum density curve, i. e., the parabola. That portion for a 1½-in. aggregate lying above the 200 mesh was selected as best suited to the office needs, the co-ordinates of the curve computed, and the logarithms taken and plotted in reverse order from the 100 per cent limit. From the curve drawn, the diagram was constructed. This diagram was reduced by photograph and printed on a filing card, 6 in. by 4 in. The card as printed ready for laboratory use is shown in Fig. 1. The heavy diagonal line represents the maximum density for 1½-in. aggregate. It is evident also that any line parallel to this line and drawn from any limiting mesh size will represent for that size the theoretical maximum

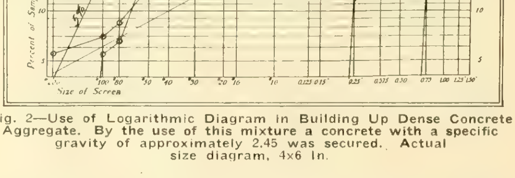


Fig. 2—Use of Logarithmic Diagram in Building Up Dense Concrete Aggregate. By the use of this mixture a concrete with a specific gravity of approximately 2.45 was secured. Actual size diagram, 4x6 In.

density curve. As can be readily seen—the logarithmic scale lends itself admirably to a close grading of the fine portion of the aggregate.

This card was first used by the office in the control of concrete aggregate used in the construction of outfall and trunk sewers in 1914. The fact that these sewers discharge into the salt water of San Francisco Bay and were designed as reinforced structures of minimum thickness, made necessary a careful control of the quality of aggregate used in order to insure maximum density and consequent imperviousness to moisture. In all this work four grades of material were combined to form the complete aggregate. In Fig. 2 are shown typical screen tests of the four component materials and of the combined aggregate as used. The concrete was a 1 to 6 mixture in the approximate ratio of 1:2:4 in which the voids in the fine aggregate averaged less than 33 per cent. By the use of this mixture concrete was secured with a specific gravity ranging between 2.43 and 2.45, as determined from samples cut from concrete in place.

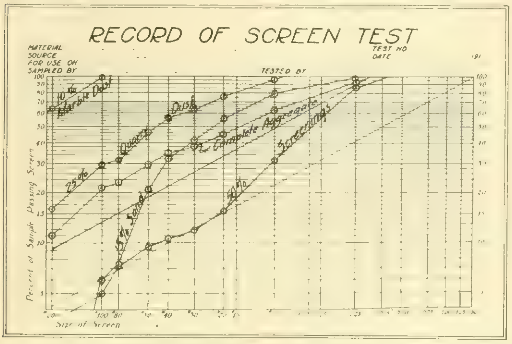


Fig. 3—Use of Logarithmic Diagram in Building Up a Dense "Topeka" Asphaltic Wearing Surface Mixture. Actual size diagram, 4x6 in.

The generally highly satisfactory results obtained in concrete construction, both as to density and imperviousness, suggested the application of the same method to grading aggregate used in bituminous paving mixtures. For the past two years it has been so used in the City of Berkeley with particularly gratifying results.

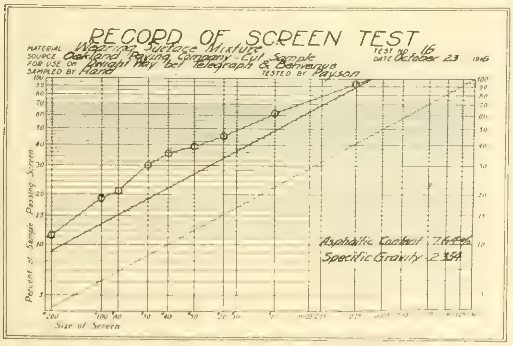


Fig. 4—Typical Analysis Diagram of "Topeka" Asphaltic Wearing Surface Sample Cut From Pavement. Actual size diagram, 4x6 in.

As an example of the value of the card in the construction of an asphalt mixture following the limits set forth in Topeka decree, it is only necessary to draw a line parallel to the heavy diagonal line, crossing the ¼-in. line on, or just above the 90 per cent ordinate. The various ordinates represent the percentages passing the various meshes for the ideal mixture. In any trial mixture it is evident that a curve concave upward, i. e., falling below this line at any point, indicates a mixture with unfilled voids. Consequently it has been the practice in this office to so adjust the mixture that when plotted it should coincide closely with the upper and lower limits of the ideal curve, with the intervening portion slightly concave downward. This insures the voids being successively slightly overfilled, without an excessive surplus of any one size. Typical screen tests of the various materials used in building up a Topeka aggregate are shown in Fig. 3, together with a combined aggregate curve. Fig. 4 is a typical curve of Topeka mixture as laid during the past season in Berkeley, from the analysis of a sample cut from the completed pavement.

In the laying of more than 350,000 sq. ft. of Topeka specification wearing surface during the past year, in which control was maintained over the mixture by sampling in the hopper at the mixer and plottting the samples according to the method outlined, the maximum variation from the predetermined curve did not exceed 5 per cent, as shown by the analysis of check samples, 1 ft. square cut from each day's run. With the materials available, it was possible to secure a resultant mixture with a specific gravity when rolled in place of between 2:34 and 2:36.

Figure 5 is a typical screen analysis of asphaltic concrete as laid during the past year. With an asphaltic content of 6.15 per cent, the finished pavement had a specific gravity of 2.40.

In all the paving work in Berkeley, the rock and sand used was of silicious, metamorphic, sandstone origin, with a specific gravity of approximately 2.62, so that the low percentage of voids obtained by this method of graduation is apparent.

Not the least of the advantages of the card, is its adaptability for office records. Each screen test as it has been made, has been properly labeled and filed so that it is possible to compare new materials with those already used and note the variation in any material at a glance, as well as to refer to any mixture previously used. These cards are now used regularly by our plant inspectors in connection with a set of screens and rough balance to control the asphaltic mixture. These plant analyses, together with the daily check analyses from the laboratory have enabled the engineer in charge to have at hand continuously exact information on the character of the paving mixture and have made possible a much more intelligent supervision of the construction work.

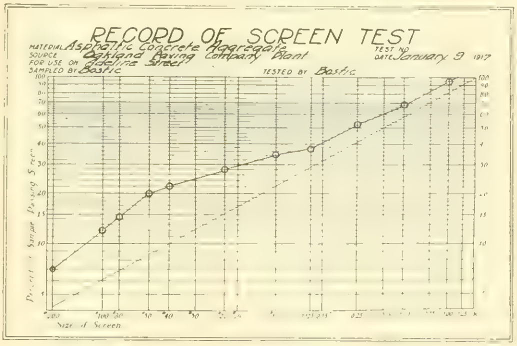


Fig. 5—Typical Diagram of Asphaltic Concrete Sample. Actual size diagram, 4x6 in.

While it is possible that with different materials from other sources some other graduation than that indicated by the curve used may produce a concrete of greater strength, the experience in this office has demonstrated that this curve produces a mixture of practically maximum density. The adoption of the diagram in convenient form has furnished a most excellent method for controlling aggregate mixtures of any type in a practical fashion, thereby insuring uniform results.

Cost of Road Surveys and Plans.—The cost of road surveys and plans made by the forces of the Wisconsin Highway Commission between Aug. 15, 1915, and July 1, 1916, under survey contracts with counties averaged $24.79 per mile. The figures in more detail, according to the Third Biennial Report of the Commission, are as follows:

	Surveys made.	Plans completed.
Miles	804.27	706.69
Cost per mile	$7.98	$16.81

RECENT DEVELOPMENTS IN DETAILS OF CONSTRUCTION OF BRICK PAVEMENTS ON GREEN CONCRETE FOUNDATION AND ON SAND-CEMENT SUPERFOUNDATION.

During the past two years radical changes have been made in the method of constructing brick pavements for streets and highways. An interesting discussion of these new methods was given by Mr. William C. Perkins, Chief Engineer, Dunn Wire-Cut Lug Brick Co., Conneaut, O., in a paper presented at the recent meeting of the American Association for the Advancement of Science. Extracts from Mr. Perkins' paper follow.

Two methods of construction are being used:

(1) The laying of the brick directly in the green or newly laid concrete, commonly called "the monolithic construction."

(2) The laying of the brick on a superfoundation of cement-sand, the cement and sand being thoroughly mixed and spread on the prepared foundation, the bricks after being rolled being well wet down, the cement and sand thus forming a mortar bed, which unites the wearing surface and the foundation. This method is commonly called "the semi-monolithic construction."

Each type has its place and the results obtained in practice are practically the same. The monolithic type is generally used in the construction of roads and streets whose width does not exceed 24 ft., and where the grades and cross-section are uniform. There are instances, however, when it has been used on wider streets with success. The semi-monolithic type is the general method used for city streets, especially if there are many intersections or much change in cross-section. Sometimes the two types are combined, a layer of cement-sand being placed on the green concrete, or on the concrete foundation before it has well set up.

From a theoretical viewpoint the laying of the brick directly in the green concrete should give the truest monolith; but the results obtained with the cement-sand superfoundation have proven that for all practical purposes as strong and rigid a pavement is obtained with this type. The engineer, therefore, in preparing his plan and specifications should be governed by local conditions as to which type to use, being assured that the essential feature of each type is a rigid beam from wearing surface to sub-grade.

Since the advent of the monolithic and semi-monolithic construction there is a tendency among paving engineers to reduce the depth of the brick from 4 in. to 3 in.

If a 3-in. brick laid directly in the green concrete, or on a cement-sand superfoundation will give as durable a wearing surface as a 4-in. brick, there would be considerable saving in the cost of brick paving, especially in districts at a distance from the brick plants. The paving engineer in preparing his estimates should investigate the saving in 1-in. of brick as compared with 1-in. of the prepared foundation, and prepare his plans and cross section of pavement accordingly.

In the manufacture of 3-in. paving brick there is a little saving in cost at the plant; the main saving, however, being in the transportation charges. A thousand 3-in. paving brick weigh about 7,500 lb. which is a saving in weight of approximately 2,500 lb. over that of a 4-in. brick. This would mean on a shipment of brick to New York City from the eastern Ohio district a saving of about 16 ct. a square yard of brick surface.

To the contractor there is a considerable saving in the use of a 3-in. paving brick. He can haul one-third more brick per load; the manipulation of handling and laying would be faster; they would require one-fourth less grout or bonding material and also require less excavation. Many engineers are taking advantage of these savings and there has been an increasing demand for 3-in. brick during the year 1916.

The actual methods of construction are in a formative state; there are isolated instances of pavements in which brick have been laid in green concrete or on a cement-sand bed; but the laying of brick in large quantities by these methods is a development of the last two years.

The first piece of monolithic roadway was laid in Edgar County, Illinois, in 1915. The inclined approaches to the Pennsylvania Railroad Terminal at 31st St. and 33d St., New York City, were laid in 1910, the brick being $2\frac{1}{2}$ in. in depth and were laid in a cement-sand bed, mixed 1 cement to 3 sand and the joints well grouted. Jacksonville, Fla., in 1912, also used a cement-sand bed under bricks in the car track area on Bay St.

Method of Constructing Monolithic Brick Pavement.

The first step in construction is a careful preparation of the subgrade. This is very important and the engineer should insist that the subgrade be free of ground water, unyielding, of uniform density and of proper grade and cross section. It should be thoroughly and uniformly compacted by rolling. Arrangements should be made and facilities provided for the drainage of all underground water. Investigations have shown that a large percentage of the longitudinal cracks in brick roads are caused by frost heavage due to a wet subgrade.

In the preparation of the concrete foundation, in order to obtain the best results, the cement, the fine and the coarse aggregate in proper proportions should be thoroughly mixed in a "batch mixer" and a regulated amount of water added so as to produce a "quaking" concrete. Care must be taken to avoid extremes, the concrete should not be too wet or too dry, and the engineer in charge should endeavor to obtain a uniform consistency of mixture.

The concrete after being deposited should be shaped roughly to proper contour and cross section with a shaping template and then cut with a steel cutting template to a cross section $\frac{3}{8}$ in. higher than the required thickness of foundation. It should then be tamped carefully to exact cross section with a striking or patting template, care being taken that this tamping template be of sufficient weight so that its center will not vibrate more than the sides.

On the monolithic roads of Illinois, where gravel is generally used in the concrete, the operation of shaping the foundation is done with a steel multiple template, consisting of two cutting or shaping templates, the rear one being $\frac{1}{8}$ in. higher than the front one, and mounted on a rigid frame equipped with rollers which move on steel side forms set to line and grade. The space between the two templates is kept filled with a dry mixture of cement and sand, and as the front template cuts the concrete to the proper cross section the rear template spreads a thin film of cement-sand over the cut concrete surface, filling all voids and smoothing up the surface. This method eliminates the human element of the final tamping and good results are obtained, especially when gravel concrete is used.

The surface of the concrete foundation should be as true to grade and cross section as it is possible to make it, as upon this depends the smoothness of the finished roadway.

The laying of the brick should follow closely the laying of the concrete foundation; care being taken that the bricks are in place before the concrete has obtained its initial set. All "batting or cutting in" should be done as the bricks are being laid and every effort should be made to lay the bricks with the best edge up, so as to avoid culling, turning of brick, etc.

Immediately after the bricks have been inspected the roadway should be rolled with a hand roller not less than 24 in. in diameter and weighing about 20 lb. per inch of length of roller. This rolling should be done as soon as possible after the bricks are laid on the green concrete so that no interval of time shall give the concrete a chance to set up before the brick are rolled into place. The bricks should be first rolled at an angle of about 45° and then thoroughly rolled in all directions until a smooth true surface is obtained.

Grouting the bricks is one of the most important steps in monolithic construction, as upon the completeness and strength of the bond depends in a great degree the life and durability of the roadway. In the preparation of the cement-grout filler, the sand should be carefully selected, and should be well graded and not too fine. The amount of water necessary to obtain the proper consistency should be determined, and so regulated as to obtain the same amount for each batch of the filler. Too much water will cause separation; too little water will cause a bridging of the joints.

The cement and sand in the specified proportions should be thoroughly mixed in a small batch mixer, properly equipped with a tank which will regulate the amount of water for each batch, and also equipped with a spout which will properly deliver the grout to the pavement.

The brick wearing surface should be thoroughly wet by sprinkling before the grout filler is applied; care must be taken that the joints are filled and that the filler extends down to the bottom of the brick and does not merely cement over or bridge the top of the joint.

After this first coat has had a chance to settle or shrink, and before the initial set develops, a second coat, preferably mixed by hand in a suitable box, should be applied, using a somewhat thicker grout; after this application the pavement should be finished to a smooth surface with a squeegee having a rubber edge which should be worked over the brick wearing surface at an angle with the joints, thus leaving them entirely filled and flush with the top of the brick.

The cement grout filler for many years has been generally specified to be mixed in the proportion of 1 cement and 1 sand; but in the last year there is a tendency among engineers to make this mixture 1 cement to 1½ sand, provided the sand is properly graded and not too fine. This change is doubtless due to the more thorough and uniform mix which is obtainable by the use of a grouting mixer.

Upon the completion of the grouting, the brick wearing surface should be inspected for slack joints, etc. A thin film of the grout left on the brick surface is not detrimental, but rather an advantage; but care should be taken that the surface of the pavement is smooth; the grout should not be left on the pavement in ridges.

To prevent a too rapid drying of the filler, a covering of hay or straw kept moist for at least two days should be spread over the brick surface. Sand or earth has been used in the past, but hay or straw gives better protection and does not add to the cost, as the hay or straw can be used to cover successive sections of pavement.

One of the many advantages of monolithic construction is that the different stages of work are all going on at the same time and practically by one organization, under one head. The contractor is working on the concrete foundation, laying, inspecting, rolling and grouting the brick within a restricted area. At the end of a day's work he should have a completed brick roadway. The work being thus confined to a small area the contractor and the inspector are able to give closer personal attention. The sections of completed roadway should be kept closed to traffic for at least 15 days.

Method of Constructing Semi-Monolithic Brick Pavement.

Many of the steps are the same as discussed under the monolithic type. The same care must be taken in preparing the subgrade, small drain pipes being used under each curb if the soil conditions are treacherous.

The concrete foundation is prepared practically the same as in the past for street paving. Its upper surface should be fairly smooth and of a uniform distance below the surface of the finished pavement a variation of ½ in. either way from the exact contour and cross section is allowable, which variation would be taken care of by the superfoundation of cement-sand.

The thickness of the foundation depends largely on local condition, the nature of the subsoil, the amount of traffic, and the cost of materials. The foundation should be designed to carry and distribute the load placed upon it and should be no deeper than is necessary to do its work. A foundation of 1-3-6 concrete is the best type for use under a brick wearing surface.

The cement-sand superfoundation, 1 in. in depth, should be considered by the engineer as 1 in. of the foundation; that is, if a 5-in. foundation is designed, the concrete should be only 4 in. thick, the 1 in. of cement-sand superfoundation being equivalent to 1 in. of concrete foundation. This is the general practice when this type of construction is used, for by the method of construction the cement-sand superfoundation sets up as hard as the concrete foundation and practically becomes a part of the same.

Several important details should be strictly followed in preparing the cement-sand superfoundation. The sand and cement in proper proportions, and a mixture of 1 cement and 4 sand is recommended, should be thoroughly mixed in a mixer until it is of uniform color throughout; experience has demonstrated that a damp sand will make a better mixture than one extremely dry. This mixture should be spread on the prepared foundation to the depth of 1 in. and carefully shaped by a template or other mechanical means to a true cross-section parallel with, and the depth of the brick wearing surface below, the cross section of the finished pavement.

It is not necessary to hand roll the cement-sand superfoundation; but the operation of shaping it is of prime importance in securing the desired smoothness in the surface of the finished pavement.

Upon this prepared superfoundation the bricks should be immediately laid, inspected, culled, and rolled. Every effort should be made to lay the brick with the best edge up, lugs in one direction, course straight, etc., so as to avoid disturbing the cement-sand superfoundation by excessive displacements and turning of bricks.

The rolling of the brick should follow closely the laying of same for the cement-sand will absorb moisture from the atmosphere and commence to harden, making it difficult to obtain a smooth, even wearing surface. A self-propelling tandem roller weighing not over three tons is recommended; in fact a lighter roller could be used if the pavement is well rolled in all directions until a smooth, true surface is obtained.

After the brick wearing surface has been satisfactorily rolled, it should be well wet down, so that the water will thoroughly impregnate the cement-sand superfoundation; care should be taken not to wash away the cement-sand from the bottom of the joint or to wash the cement away from the sand, but the water should be applied with judgment and in the proper quantity so that the cement-sand superfoundation will absorb sufficient water to become a mortar of equal consistency throughout and eventually "set up," uniting the brick wearing surface and the concrete foundation together.

During the wetting down of the brick if the engineer or inspector will "pull" two or three bricks he can readily determine from inspection if the water is thoroughly penetrating the cement-sand superfoundation and thus regulate the amount of water applied, but it is of the greatest importance that enough water be applied to make a plastic mortar of the cement-sand superfoundation.

In some instances engineers sprinkle the prepared concrete foundation and also the prepared cement-sand superfoundation with a thin mixture of cement and water, believing that a stronger bond between the concrete foundation, cement-sand and brick wearing surface is obtained.

While it is not absolutely necessary to grout the brick surface immediately, better results are obtainable if the grout is applied the same day the bricks are laid; for then the grout in the joints of the brick will effect a union with the cement-sand superfoundation before the superfoundation sets up and thus will make a better bond between the brick wearing surface and the superfoundation.

The method of preparing the cement grout and its proper application is the same as for the monolithic type and all details should be carefully followed.

South Carolina has marked the poles and signboards along the main roads by colored bands indicating the various routes of which the roads forms parts.

CLEANING PAVING BRICK BY COMPRESSED AIR POWER.

Contributed by C. G. Cummings, 30 Church St., New York

During the past few years an increasing variety of practical uses has been found for a portable, self-contained, motor-driven or engine-driven air compressor which can be readily moved about from place to place to furnish compressed air power for different purposes. Such purposes include the operation of hammer drills for rock excavation in road work, cutting trenches for water, sewer and gas pipes, removing old asphalt or concrete pavement, operating riveters for structural steel and bridge work, driving hammer drills for building foundations, block-holing boulders in quarries, street grading, etc., etc.

An interesting application of one of these outfits was developed some four years ago by Mr. C. F. Crowley, Commissioner of Public Works, of the city of Troy, N. Y. This consists in removing and cleaning old paving brick. The equipment used for this work, which was purchased in 1913, consisted of a 15-H.P. Sullivan Class WK-3, portable, single stage air compressor, the compressor being operated by a gasoline engine, mounted on the same truck with the compressor as shown in Fig. 1, and operating the compressor through a gear and pinion.

Fig. 1-3—Outfit and Methods for Cleaning Paving Brick by Compressed Air Power.

This outfit furnished compressed air for a Sullivan "DA-15," 25-lb. plug drill, and a Sullivan "DB-13" hand bushing tool equipped with bits like that on a cold chisel. The larger of the two tools is used for tearing up the brick, and the smaller for cleaning the old mortar and grout from them. With the plug drill one man can remove 4 sq. ft. of pavement in 15 or 20 minutes, taking the bricks up either one brick at a time or several, as desired. When doing this work by hand, the workmen were frequently obliged to break several bricks, which were perfectly good, in order to get out one, so that the loss was considerable.

Before the purchase of this outfit the cost of removing and cleaning bricks by hand was $24 per thousand and a crew of 10 men was able to handle about 1,000 bricks per day. The detailed cost of operating the compressor and drill outfit was as follows:

1 compressor engineer	$3.00
7 gallons of gas at 18 ct.	1.26
4 operators at $1.85	7.40
Lubricating oil	.25
Total cost per day	$11.91

The above, of course, does not include interest or depreciation. Mr. Crowley estimates that about 2,000 bricks are removed and cleaned in eight hours with the two tools, which are shown at work in Fig. 2. This brings the cost of taking up and cleaning to $5.96 per thousand bricks. On work done with this outfit in 1914 a crew of 40 men was cut down to 18 men. It is estimated that this outfit pays for itself on every 100,000 bricks taken up and cleaned. Savings included labor on the brick, saving in the sand cushion, saving in time in making the bed under the brick and in laying the brick. Cement and grouting are also saved.

Mr. Crowley gives the following table showing the number of bricks cleaned each year and the saving made by the use of this outfit:

	Brick cleaned.	Saving.
1913	229,000	$ 4,122
1914	82,200	1,480
1915	356,000	6,400
1916	100,000 (Est.)	1,800
	767,200	$13,802

The Sullivan portable compressor and hammer drill at Troy have been used by other city departments, including the Water Department, for cutting pipe trenches in rock and other light rock excavation.

MAINTENANCE OF EARTH AND GRAVEL ROADS.

Any discussion of the maintenance of earth and gravel roads must necessarily contain much elementary information. Nevertheless, this work is so universally neglected that some of these elementary principles may well be brought to the attention of highway engineers. An excellent paper on this subject was presented on Feb. 7 at the convention of the American Road Builders' Association by R. L. Morrison, Professor of Highway Engineering, A. & M. College of Texas. An abstract of Prof. Morrison's paper follows:

Earth Road Maintenance.

The first maintenance operation should usually consist of shaping up the road with a grader and under ordinary conditions this should be done once or twice a year. The road grader is a very effective machine if properly used, but should be in charge of a skillful and sensible operator. Cutting should usually begin at the sides, and if the roadside is covered with sod and weeds the blade should be set on the first round in such a way that this material will be scraped into the ditches instead of onto the road. It can then be removed with shovels. Sometimes the entire road surface is covered with worn-out material mixed with dead leaves, manure, etc., and in that case, this layer of worthless material should first be scraped into the ditches, or else into windrows, and then carried away in wagons. Such detritus not only makes a poor road surface, but it washes to the sides and hastens the growth of sod and weeds, which seriously interferes with proper crown drainage. Often this growth on the shoulders can be removed to advantage with a spring-tooth harrow or hand cultivator. Whatever the means employed, care should be taken to see that this material is entirely removed from the roadway and ditches.

A common mistake is to make the width between ditches too great. A width of from 16 to 24 ft. is usually sufficient, and unnecessary width means additional expense for maintenance. If the roadway has been made too wide in the first place, new ditches should be made nearer together. Stakes should be set to guide the workman, and, if necessary, a plow should be used to loosen the earth at the sides.

In shaping up the road with a grader, some operators begin at the sides and use the entire width of the blade, if possible, the blade being set almost at right angles with the center line of the road so that enough material is carried along to fill up the ruts and holes. Other operators begin just outside of the wheel track and work toward the side instead of beginning at the sides and moving a constantly increasing mass of earth. Instead of using the entire width of the blade they raise the heel, thus allowing the earth to pass under the heel of the blade. This tends to break up clods and puddle the material. Whichever method is used, enough material is moved toward the center at each round to build up a proper crown, but it must be remembered that a crown of 1 in. to the foot is sufficient and it should not be made any steeper. A steep crown forces all traffic to follow in the same tracks, which rapidly forms ruts. Distributing the traffic over the surface helps to save the road.

The road grader should be properly cared for. The blade should be kept sharpened, and worn-out blades should be renewed promptly. In many places the use of traction engines or road rollers to pull graders has proved economical, one engine often pulling two graders.

The proper use of a road drag is so generally understood that it is hardly necessary to discuss it. It may be well to state, however, that wonderfully efficient as it is, the road drag is endowed with neither brains nor judgment, and if these are not possessed by the operator, good results can hardly be expected. Often the drag is used at the wrong time, or in the wrong way, or only once or twice when it should be used many times.

To the engineer or road superintendent who understands what should be done to the earth road, the problem is mainly one of organization, and the greatest obstacles are apt to be legal rather than technical. The old system of working out road taxes was discarded in France over 150 years ago because of its obvious inefficiency, but in most parts of the United States this antiquated system is still firmly implanted. This makes the situation discouraging, but not hopeless. The work can be carefully planned ahead, the road hands can be called out a few at a time, and can be worked under experienced foremen who are continuously employed.

In many states contracts are made with the farmers to drag the roads near their farms at a certain rate per mile or per hour. If a county is divided into districts in charge of competent foremen the farmers in each district can be called out by telephone at the proper time and the work can be inspected by the foremen. The road dragging usually inerferes very little with the farmers' regular work.

If the district foremen are regularly employed and supplied with teams, tools, and extra helpers as required, their work supplemented by the dragging done by the farmers, will keep the roads in excellent condition at a comparatively low cost. Each district should include 20 to 30 miles of road.

Another system which seems to be efficient is a part-time patrol system under which the roads are divided into short sections, usually 3 to 5 miles in length, and a man supplied with the proper tools is put in charge of each section. This differs from the regular patrol system in that the man does not devote his entire time to the care of the road, but his other employment is made secondary to the road work.

Many engineers claim that the ordinary continuous patrol system is not adapted to the maintenance of earth roads, but experiments by the Office of Public Roads seem to indicate that this system is at least worthy of consideration in that connection.

Gravel Road Maintenance.

With this type of road the regular patrol system seems to be the most economical and efficient, the patrol sections being from 5 to 10 miles in length. This is especially true because a small hole in a gravel road, unless immediately repaired, soon becomes a large hole. A few large holes mean a ruined road and a large expense for resurfacing.

The greatest amount of maintenance work is required during the first few months after the road has been built, before it has become thoroughly compacted and settled by traffic. The surface is likely to become badly cut up in wet weather, and to ravel in dry weather. The first condition is most likely to occur if there is too much clay in the gravel, and the second, if there is too little clay. During this time a road grader is usually the best tool to use, as the blade will cut off high spots, fill up hollows, and keep the crown shaped up more effectively than a drag. Opinions differ, however, as to comparative value of the scraper and the drag for this work. The crown should be about ¾ in. to the foot, giving, for instance, a crown of 6 in. on a 16-ft. road. If the crown is made steeper than this, traffic will all keep to the center of the road and quickly form ruts.

If the gravel contains a great excess of clay it will be necessary to add a thin layer of sand-gravel free from clay. If, on the other hand, the gravel does not contain sufficient clay to properly bind the surface, a layer of clay may be added and harrowed into the gravel. Usually from 10 to 20 per cent of clay makes a satisfactory binder. If the surface does not immediately "set up" it should not be hastily concluded that there is too little binder; in fact, a road which sets up too soon is apt to cut up later on.

Scraping or dragging should be done immediately after a rain, while the road is soft enough to be worked. A scraper has some effect upon a dry road, especially where the gravel is displaced through lack of sufficient binder, but a drag should always be used when the road is wet. At first the scraping or dragging should be done after every rain, and scraping may be necessary between rains, but as the road becomes compacted by traffic, this work need not be done so often. After the first few months a drag will be as effective as a scraper, but the cutting edges of the drag should be protected by iron over their entire length.

Although the drag will keep the surface smooth and fill up small depressions, it is usually necessary to do more or less patching. The patrolman can go over his road during or just after a rain and locate the depressions by the standing water. If there is any mud in the hole it should be carefully cleaned out and the bottom should be loosened up with a pick. Unless the road is wet the hole should be thoroughly sprinkled before it is filled. This loosening and sprinkling will insure a bond between the old and the new material. Large stones should not be used in shallow depressions, and the top of the finished patch should be just high enough so that it will be even with the road surface when compacted. If it is left too high, holes will be formed at each end of it where the wagon wheels drop off.

Piles of gravel should be left at intervals of about ½ mile along the roadside, to be used for patching, and enough material should be left in each pile so that it will not be scattered before it is used. This gravel should, if possible, be the same material as that used in the original construction.

When the surface becomes so badly worn that patching is no longer sufficient, the road must be entirely resurfaced. This work can best be done in the spring when the road is comparatively soft. All vegetable matter and other refuse should first be removed from the road surface, and then the old gravel should be scarified and reshaped before the layer of new material is put on. The scarifying can often be done with a heavy harrow. If the harrow brings large stones to the surface they should be removed. Before the new gravel is put on, the old surface should be well sprinkled to insure a good bond with the new gravel, and, if possible, it should also be rolled. The new material, similar to the top layer of a new road, is then put on, shaped, and, if possible, rolled. The surface should be kept smooth with a scraper or drag until it is well compacted.

Sometimes a road wears out sooner than it should because it is too narrow. On a narrow road vehicles are forced to follow the same track and ruts are formed much sooner than if there is an opportunity for the traffic to spread out over a wider surface. If the road is too narrow the new surface can be extended out beyond the old one at the sides. There will be less traffic on the sides than near the middle, so that it will do no harm to have this portion thinner than the rest.

It will add to the life of a gravel road to roll it every spring, whether extensive repairs are made or not, and it is also a good plan to roll it after the first rains in the fall. The rolling should be done when the road is fairly soft, but not while water is standing upon it.

The dragging and small repairs needed annually cost as a rule from $20 to $50, though sometimes $100 or more per mile per year. Re-surfacing usually has to be done at intervals of from 5 to 10 years at a cost equal to about two-thirds of the cost of the original gravel surface. Dividing this cost by the number of years between resurfacing, and adding the annual cost of dragging and small repairs, gives a total annual cost of from $150 to $300 per mile to keep the roads in first-class condition perpetually.

Apparently an ordinary gravel road will not carry economically more than about 150 motor cars per day without a bituminous surface treatment. Heavy asphaltic oils and tars have been used for this purpose with success, but satisfactory results are not as easily obtained as in treating macadam roads. A double treatment first with light tar and then with a heavier tar, has proved satisfactory, even on a poor grade of gravel and a double treatment of oil has also been successfully used.

WIDTHS OF WAGON TIRES SUITABLE FOR USE ON COUNTRY EARTH AND GRAVEL ROADS.

Standard widths for wagon tires are recommended in a circular prepared by E. B. McCormick, Chief Division of Rural Engineering, Office of Public Roads and Rural Engineering, issued Feb. 12 by the U. S. Department of Agriculture. The recommendations are based upon two factors: (1) The unit weight of tire commonly used for road rollers and (2) the results secured from a large series of tests conducted by the U. S. Office of Public Roads and Rural Engineering. The recommendations follow:

While there has been in the past, and to a certain extent still is today, wide variation in sizes and types of wagons marketed by the different manufacturers, it is believed that five sizes of wagons will be sufficient to meet all the needs of farming operations and all general work except the heaviest trucking and certain specialized hauling, which is likely to be confined to city pavements. These five sizes are:

(1) One-horse wagon having a gross load capacity of 2,000 lb. and a skein from 2⅛ to 2⅜ in.

(2) Light two-horse wagon with a skein approximately 2½ in., and a gross carrying capacity of 3,500 lb.

(3) Medium two-horse wagon with a skein not exceeding 3 in., and designed for a gross load of 4,500 lb.

(4) Standard two-horse wagon with a skein of 3¼ in. and a gross carrying capacity of 6,800 lb.

(5) Heavy two-horse wagon having a skein of 3½ in. and gross load capacity of 7,500 lb.

As there is considerable difference in the practice of manufacturers regarding the size of skein used on the various types of wagons, it is recommended that wagons be not designed by size of skein but according to the gross load capacity, and that a name be adopted for each of the sizes. It is further recommended that the gross carrying capacity of the wagon be shown by stencil or plate on the back of the rear axle. The following widths of tire are recommended for each size of wagon:

Size of wagon	Gross weight, loaded. Lb.	Width of tire. In.
One-horse wagon	2,000	2
Light two-horse wagon	3,500	2¼
Medium two-horse wagon	4,500	3
Standard two-horse wagon	6,800	4

The 13 cars of the Operating Department of the city of San Diego, Cal., during the month of January covered 14,297 miles at an average cost of 5.3 cts. per mile, or $51.22 per car, repairs, tires and oil and gas included.

The maintenance of the 88 head of stock used in the street bureau of San Diego, Cal., including feed, horseshoeing and care, averaged $26.50 per head for the month of January.

CONCRETE ROAD CONSTRUCTION IN NEW YORK.

The essential features of concrete road construction were outlined by W. M. Acheson, Division Engineer, New York State Commissioner of Highways, in a paper presented at the 13th annual convention of the American Concrete Institute. In his paper Mr. Acheson brought out a number of points on the New York practice in work of this kind. Some of these are quoted below:

Where soil conditions developed that cannot be corrected by replacing with more stable soil, subbase should be laid. From a study of the highways which were built in Division 9 during the past two years I have found the following type of foundation course the best for cement concrete pavements:

After the necessary excavation has been made and properly drained a layer of clean gravel from 2 to 4 in. in thickness is spread over the bottom. On this place a quarry or field stone course of the required thickness, depending upon the soil conditions.

After the voids have been filled with clean sand or fine gravel and consolidated it should be covered with at least 2 in. of coarse sand. This last mentioned sand layer serves the double purpose of regulating the subgrade and acting as a cushion to take the impact off the pavement proper.

Concrete roads should be reinforced with a light mesh reinforcement when bad subsoil conditions are encountered. We are using reinforcings every place there is any doubt, and sometimes use it in conjunction with the foundation course, and also thickening of the slab.

One of the essential features of the reinforcings is to be sure the reinforcement is in its proper location as to cross section.

It has been our practice to lay the first course of concrete and on this place the reinforcement, usually about 2 in. below the subgrade, by the use of wire hooks; it is then covered with the necessary 2 in. of concrete and struck off to the finished section.

In the preparation of the subgrade great care should be taken by the contractor to see that at all times proper lateral ditches run from the subgrade to insure quick drainage after a rainstorm. In the subgrade it has been demonstrated that a flat subgrade is the ideal type for a concrete road, and this is the reason that lateral trenches from the subgrade to the ditches are not only necessary during the construction period, but can be used later as side drains to aid in keeping the foundation course dry.

I believe the most important feature of mixing concrete is, first, the number of revolutions based on the time which the mixer turns in order to turn out a batch of concrete. Second, the water. I place the number of revolutions first for the reason that by giving the mixer a few revolutions and excess of water you would have the appearance of good concrete, but by giving the required amount of revolutions which practice and experiments have shown to be necessary the water situation solves itself, and I believe in this connection that the minimum revolutions of the drum should be 12 and the minimum length of time 55 seconds.

The concrete should be a "quaky" mixture; not wet enough for the mortar to run away on the subgrade, but plastic enough to be easily worked. It is absolutely necessary to procure this result that the correct quantity of water be determined and its use of volume practically constant, and the condition of the aggregate will mean in some cases the change in the volume of water. Care is always necessary that the aggregates are accurately measured. These are the essential features of good concrete construction.

In the installing of joints, whether a pre-molded joint, a wood joint or a steel joint, great care should be taken that the joints reach to the subgrade in the case of the three types, and in the wood and pre-molded joint it should project at least ¼ in. above the finished pavement, and a split float used to insure the plane being continuous to the slabs. These joints may then be cut off to conform to the section of the road.

In the case of the steel joint great care should be taken to see that the camber of the steel joint and the camber of the screed used are identical, and these joints should at all times be laid perpendicular to the axis of the road and perpendicular to the plane of the road.

Unless these joints are carefully installed as above there will be a tendency for one joint to slip against the other, especially on grades.

The surface of a concrete road should be screeded by means of a template at practically right angles to the axis of the road, with a short, sawing action. A heavy screed should be used, and at the same time it should not be necessary to move this screed over the concrete surface more than once; following this should be the smoother. This is frequently referred to as a float, but the word float is a misnomer. The real intention is to smooth the surface so it will conform to the finished section. This smoothing tool should at all times be made of wood.

Sprinkling with hand pots should be started as soon as the concrete surface will stand it. In this case I mention hand pots for the reason that the pressure from a hose on the first sprinkling is usually too severe on the surface; this should be done from one to two hours after the concrete is placed. In this connection it is very essential that this hand sprinkling should be done several times before sod or earth protection is placed over the surface, and then after it is placed should be sprinkled at least twice during the day and once at night.

In the curing of concrete roads judgment and common sense enter into this feature very strongly, for, with hot suns and drying winds to contend with, unless the curing is properly looked after a serious damage will be done to the road surface.

Under favorable conditions a concrete road should be closed to traffic from 10 to 14 days, and in the fall or a slow-curing period it should be kept closed three weeks.

On the roads which have been constructed in New York state, with one exception the material has been delivered on the finished subgrade in windrows, the stone on one side and the sand on the other; care has always been taken that these materials should never become mixed before being proportioned for the mixture.

The organization has generally been, one man sprinkling and throwing one cover, one man smoothing, two men on the screed, three men in front of the mixer spading the concrete to conform as nearly as possible to the section required, and two operators on the machine—one on the supply bucket and one depositing the concrete.

Behind the machine, from 15 to 20 men, depending absolutely upon the life which the foreman in charge instils into his gang.

The materials are so distributed that the wheeling distance is as short as possible at all times, and by this I mean 50 ft. from the mixer.

I believe in a heavy split float for taking care of the joints, and a long-handled float which enables the operator to always work in a normal position over the bridge, and at the same time eliminate an additional man, which is necessary when hand floats are used.

It has been demonstrated to our satisfaction that it is necessary to give the mixer drum at least 12 revolutions. Materials as called for in our specifications and mixed 12 revolutions have shown an average compression test for 1:1½:3 mixture, 28 days old, of 3,500 lb. per square inch, and in many cases have shown compressive strength of 5,400 lb. per square inch for the same period of time.

The material as coming from the concrete mixer should be deposited so it is of such consistency that the mortar does not run away from the coarse aggregate. The material as deposited is handled by three men in front of the mixer, in order to make the screed do as little as possible. The finishing should always be within 10 to 15 ft. of the screed, and this is impossible if the concrete is too wet.

At the joints a split float should be used in order to insure the road having a continuous plane for the finished pavement. I advocate the brooming of a concrete road for the reason that the marks which the broom makes in the pavement aid in holding the moisture longer during the curing season. Care should be taken, however, to see that the broom marks are not too deep, so as to start spalling and impede the surface drainage.

Our roads are covered with loam, sod or any soft material and wet down twice a day in the hot summer. In the fall we have constructed pavements which we placed no cover on at all, but which were wet down at least once a day.

One of the most important parts of a contractor's road plant in the construction of cement concrete roads is the water supply. I would advise at least a 5-hp. engine with a pump capacity of at least 200 gal. per minute.

The pipe line should be at least 2-in. pipe and should have a tap at least every 200 ft. Wire-wound hose should be provided, long enough to reach half way between the taps. A great many mistakes have been made in the past in regard to this particular feature.

MAINTENANCE OF PARKING STRIPS.

Contributed by H. R. Ferriss.

In many cities, where the boulevards or parking strips are maintained at the expense of the rate payers, the cost of water used for irrigation is usually a serious item, and has frequently provoked discussions as to the advisability of metering the connections. However, nearly all boulevards, especially old ones, are irrigated by individual connections to the mains, and the cost of installing and maintaining the large number of meters that would be necessary on individual connections is usually regarded as prohibitive. In the absence of meters it is particularly necessary that every means be taken to avoid waste.

The following remarks may therefore not be out of place:

First, last, and all the time, employ a capable foreman in charge of the watering crew.

The adoption of a system of small fines for carelessness, together with a bonus, will frequently work out, and when this system can be successfully used it will accomplish a great deal in the way of a number of economies. It is generally more satisfactory to fine a man for carelessness in the use of water than it is to discharge him and spend time in breaking in a new man who may develop the same faults. A corresponding bonus should be given for lack of apparent waste, for care in the use of hose, and other equipment, and for the general appearance of the grass, that is, the greenness and freedom from burnt spots, or otherwise there might be a certain temptation to avoid the possibility of a fine by "skimping" on the water at the expense of the grass.

As most boulevards are long, narrow strips, the selection of the proper type of sprinklers is very important. The ordinary round sprinkler, if operated in such a manner so as to cover all the grass, will waste a large quantity of water by overlapping and by sprinkling the edge of the pavements and the sidewalks. The use of a long, narrow sprinkler, such as can be made by boring holes in a length of ¾-in. pipe with the ends plugged, will usually give satisfactory results if the pressure is good.

Watering should generally be done in the early morning and in the late evenings.

As a general thing when boulevards are constructed they are built with a slight camber to provide for drainage. This, in the writer's opinion, may frequently develop into a fault, as it allows the water used for sprinkling to run off to the curb before it has had time to soak into the ground. A sag of about ½ or ¾ in. between the two margins of the grass strip is not enough to seriously affect the run-off during a heavy rain, and does result in a decided saving in the amount of irrigation necessary, as it tends to hold the water. It also allows a space for the fertilizer or top dressings which may be added from time to time.

Usually one man can handle two lengths of hose with automatic sprinklers, in addition to one length with a hand sprinkler.

At the time of construction care should be taken to see that the boulevards are well built and that a proper depth of rich, black loam is placed on the grass areas. In general, it is advisable to undercut at least 6 in. and refill with loam and plenty of good fertilizer. The extra initial expense will be more than recovered in the cost of water and fertilization, which will subsequently be saved.

The construction of boulevards is only too often "scamped." Well constructed boulevards bring in good returns in every case. Fertilization properly applied every year is also good economy. Weeding should usually be done in the early spring, as soon as the frost has left the ground.

RECENT PRACTICE IN THE CONSTRUCTION OF GRANITE BLOCK PAVEMENT.

The recent practice in the construction of granite block pavement is described by William H. Connell, Chief, Bureau of Highways and Street Cleaning, of Philadelphia, Pa., in a paper presented Feb. 8 at the convention of the American Road Builders' Association. An abstract of Mr. Connell's paper follows:

In order to obtain the best results in granite block construction, the first step naturally is to determine upon the specification for the block itself. The American Society of Municipal Improvements has adopted the following specifications for a standard block, as being cut by the majority of the quarries in the United States.

> The blocks shall be not less than 3½ in. or more than 4½ in. wide on top, not less than 4¾ in. or more than 5¼ in. in depth and not less than 8 in. or more than 12 in. long. The blocks shall not show a variation of more than ⅜ in. on the head under a straight edge. They shall be so cut that they can be laid with joints not exceeding ½ in. in width.

The Borough of Manhattan, New York City, has adopted the following specifications:

> The block shall be not less than 6 in. or more than 10 in. long, not less than 3½ in. or more than 4½ in. wide, and not less than 4¾ in. or more than 5¼ in. deep. The contractor shall select a definite width for the blocks to be used on each city block within the limits of this contract and notify the engineer of such selection. All blocks shall be of the selected width with an allowable variation of ¼ in. either way from this width, but within the limits for width of blocks specified above. The blocks shall be approximately rectangular on top and sides and uniform in thickness. They shall be so cut that the joints between individual blocks when laid shall average not more than ⅜ in. The head of the block shall have no depression greater than ¼ in. from a straight edge laid in any direction and parallel to the general surface of the block.

The city of Philadelphia has adopted a specification which is a mean between the specification adopted by the American Society of Municipal Improvements and the Borough of Manhattan.

> The blocks shall be approximately rectangular on the top surface and sides and uniform in thickness. The size of the blocks shall be as follows: Not less than 6 in. nor more than 10 in. in length and shall average not more than 9 in., not less than 3½ in., nor more than 4½ in. in width and not less than 4¾ in., nor more than 5¼ in. in depth. The contractor shall select a definite width for the blocks to be used in each city block within the limits of the contract. All blocks shall be of the selected width, with an allowable variation of ¼ in. either way over this width, but within the limits for width of block as previously specified. They shall be so cut that the joints between the individual blocks when laid shall not exceed ½ in. and shall average not more than ⅜ in. The top surface of the block shall have no depressions greater than ⅜ in. from a straight edge laid in any direction and parallel to the general surface of the block. Not more than one drill hole shall show on the head of a block, and none on the ends. An average allowance of not over one block, showing drill hole on side, shall be permitted to a square yard of laid blocks. Unless otherwise stated in the proposal, it is understood that this type of block will be used on all contracts for granite block pavements.

Philadelphia has also adopted the following specification, which it is felt will be very advantageous to be used in resurfacing old brick and asphalt block streets, if desired, on the present concrete foundations:

> The blocks shall be approximately rectangular on the top surface and sides and uniform in thickness. The size of the blocks shall be as follows: Not less than 6 in. nor more than 10 in. in length, averaging not more than 9 in., not less than 3½ in., nor more than 4½ in. in width and not less than 3 in. nor more than 3½ in. in depth. All blocks shall be of selected width, with an allowable variation of ¼ in. for either way over this width, but within the limits for width of block as previously specified. They shall be so cut that the joints between the individual blocks when laid shall not exceed ½ in. and shall average not more than ⅜ in. The top surface of the block shall have no depressions greater than ⅜ in. from a straight edge laid in any direction and parallel to the general surface of the block. Not more than one drill hole shall show on the head of the block, and none on the ends. An average allowance of not over one block, showing drill hole on side. shall be permitted to a square yard of laid blocks.

A great many quarries are also cutting blocks of the following dimensions:

> The blocks shall not be more than 4 in. or more than 4½ in. wide on top, not less than 4 in. or more than 4½ in. deep, not less than 8 in. or more than 12 in. long, and they shall be so cut that they can be laid with a ½ in. joint, and shall not show a variation of more than ⅜ in. on the straight edge under the head of the block.

If blocks of these various dimensions are called for and the inspection and methods of handling are sufficiently rigid to insure their conforming with the specifications, and great care is taken in the inspection of the construction of the pavement, there is no question about obtaining a first-class job.

Great care should be taken in the handling of the blocks to avoid chipping. Arrangement should be made to carefully unload the blocks from the boats or cars and immediately place them in the conveyances to haul them to the site of the work where the same care should be exercised in their unloading and handling. Rear-end dump vehicles should be used as drop bottom wagons unnecessarily damage the blocks. In all cases, the rehandling of blocks should be reduced to a minimum.

The standard practice today specifies either a 1-in. sand cushion or 1-in. 1 to 4 cement sand cushion laid dry. A number of the larger cities are rather inclining to the cement sand cushion in preference to the ordinary sand cushion as it is felt that weaknesses are less apt to develop due to shifting of the sand cushion. The Borough of Manhattan, New York City, the city of Baltimore, the city of Philadelphia and a number of other localities have recently adopted the cement sand cushion.

The standard practice with reference to the grout for the joints calls for a 1 to 1 cement grout mixture. There have been a number of experiments in recent years with a mixture of bituminous material and sand for fillers. These experiments were undoubtedly carried on more extensively in the Borough of Manhattan, New York City, than any other place and to a somewhat limited extent in the city of Philadelphia and other cities.

These fillers consist of different mixtures, ranging from 30 to 40 per cent of sand mixed with bituminous material—either tar, asphalt or asphalt and tar mixed. In Baltimore they have obtained very good results with an asphalt filler used in the following method: They pour hot asphalt to a depth of 1 in. and about 1-in. depth of hot gravel, and repour and refill with hot asphalt and hot gravel alternately until the joints are flush. This usually takes approximately four pourings. After the joints are filled, the hot asphalt is squeegeed over the entire surface of the blocks and hot gravel is then thrown over this before traffic is allowed on the pavement. This gives an asphalt surface of about ⅛ in. on top of the granite block, giving the street the appearance of a sheet asphalt pavement.

In using the mixture of sand and asphalt such as has been used in New York, the block is also covered to a certain extent with the bituminous mixture. In some cases it has been squeegeed over the entire surface. The object in the Borough of Manhattan and the city of Philadelphia, however, is not to do any more than fill the joints with the bituminous filler.

The best results in granite block construction are undoubtedly obtained with the cement grout filler, and it would seem to be good practice in every instance to make arrangements to close the street the additional seven to ten days and construct the pavements with grout fillers. Of course, there are some streets that it is practically impossible to keep the traffic off for this length of time, and in such cases it will be necessary to use the bituminous filler, but there are a number of instances where bituminous filler is used, where the traffic conditions have been such that the street could be closed for a long enough time to use the cement grout filler.

The old method in using cement grout filler was to fill the joints for a certain depth with pea gravel and then pour the cement grout filler. It has been found, however, that better results are obtained by eliminating the gravel entirely and filling the whole joint with the 1 to 1 mixture, and this method is used exclusively in a number of cities. There has been considerable discussion relative to the best means for mixing the grout. Of course, just as good grout can be mixed by hand as by machine, provided it is given the proper attention, but more uniform results will be obtained by adopting the machine mixing method, as this eliminates the human element which often is not properly controlled.

The cement grout, of course, must be kept thoroughly agitated until it is poured into the joint, and the blocks should be thoroughly sprinkled before the filler is placed in the joints. The following is the method of pouring the grout in the city of Philadelphia and is more or less standard:

> Immediately after the blocks are laid they shall be rammed so as to leave no blocks above or below the general surface of the finished pavement. After the blocks have been brought to a uniform surface, and wetted by sprinkling with water, grout filler, composed of 1 part of Portland cement and 1 part clean, sharp sand mixed with clean, fresh water, shall be broomed into the joints, and the operation shall be continued as the grout settles, until the joints are thoroughly filled flush with the surface of the blocks, immediately after which the entire pavement shall be broomed to a smooth surface, sufficient grout being applied to bring the surface even with the highest part of any of the blocks. A squeegee scraper shall be used in the last application of the grout. In mixing the grout mechanical grout mixers of a type to be approved by the engineer shall be used. The sand and cement must be measured previously to being placed in the machine, after which water shall be added in a quantity sufficient to give the grout the proper consistency. Care must be exercised to insure that the mixing is continued for a sufficient length of time, and in no case shall this time be less than one minute. If the grout has to be carried for any considerable distance from the point of mixture, it must be carried in water-tight carts properly equipped to automatically agitate the grout during its transportation from the mixer to the point of application, or, in lieu of this, the grout must be thoroughly agitated by hand just previous to its application. Special care must also be exercised to insure that the grout as applied on the work is of a uniform consistency. Within one-half to three-quarters of an hour after the last application has been made and the grout between the joints has fully subsided and the initial set is taking place, the whole surface shall be lightly sprinkled with water, and the surplus grout left on the top shall be swept into the joints, bringing them up flush and full. After the grouting is done and a sufficient time for initial set has elapsed, so that a coating of sand will not absorb any moisture from the grout, ½ in. of sand shall be spread over the whole surface. When the work is subjected to an air temperature of 75° F. or more, the sand shall be sprinkled three times a day for three consecutive days. The highways shall be kept closed to traffic for at least seven days. Should the bond between the blocks become broken, the joints shall be cleaned out, even if it is necessary to take up and relay the blocks. The part so taken up and relaid shall be regrouted and protected for at least seven days until hardened.

COST OF OPERATION OF MUNICIPAL ASPHALT PLANT OF LOS ANGELES.

The Street Maintenance Department of the city of Los Angeles, Cal., operates its own asphalt plant for supplying materials for patching pavements. The detailed cost of operation of the plant for the fiscal year July 1, 1915, to June 30, 1916, according to figures furnished by Homer Hamlin, City Engineer, was as follows:

	Surface mixture.		Bitulithic mixture.		Binder mixture.	
	Cost.	Cost per cu. ft.	Cost.	Cost per cu. ft.	Cost.	Cost per cu. ft.
Labor	$ 9,419	$0.0281	$54	$0.0213	$287	$0.0263
Asphalt	14,025	.0418	59	.0234	223	.0201
Dust	7,383	.0220	36	.0140	...	.....
Sand	6,114	.0182	22	.0085	72	.0066
Rock	...	.....	65	.0258	402	.0367
Fuel	1,875	.0056	16	.0061	47	.0043
Power	455	.0014	2	.0010	14	.0013
Supplies and expense	407	.0012	1	.0006	18	.0016
Plant maintenance	1,965	.0059	4	.0015	71	.0065
Administration, interest and depreciation	4,037	.0120	29	.0114	83	.0076
Total cost	$45,679	$0.1362	$289	$0.1139	$1,216	$0.1115
Output for year (cu. ft.)	335,310		2,540		10,910	
Cost per cu. ft. (ct.)	13.62		11.39		11.12	

The output was increased from 40 per cent of the plant capacity for 1914-1915 to 50 per cent for the last fiscal year. This reduced the cost of production 1 ct. per cubic foot.

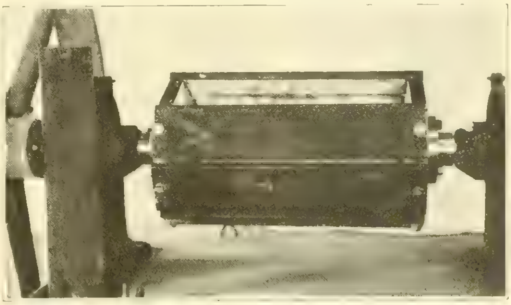
AN IMPROVED ABRASION TEST OF STONE FOR ROAD AND CONCRETE PURPOSES.

A new machine for making abrasion tests of work has been devised by H. H. Scofield, Assistant Professor of Civil Engineering at Purdue University. In a paper presented at the recent meeting of the Indiana Engineering Society Prof. Scofield describes the machines and gives the results of test made with it. An abstract of the paper follows.

The principle of action of the machine is that of the brick rattler in that its sides are straight metal pieces with spaces between to allow for the escape of the dust. Its cross section is octagonal and its internal volume was made equal to that of the Deval cylinder. Its length is also the same as that of the Deval cylinder. The space between the staves or sides of the chamber is ¼ in., allowing for free passage of dust and particles up to that size.

It was the purpose, at first, to use this abrasion chamber in a Deval frame so that the motion and movement of the charge would be similar to that in the regular test, but later in order to make a simpler and more compact machine, it was so arranged that it revolved about its own longitudinal axis in a horizontal position. It was also thought that, operated in this latter position, it would be necessary to employ an abrasion charge as in the standard brick rattler test, in order to give an appreciable loss during the test. This was erroneous, however, as the results show.

The number of comparative tests already made with this machine are not many, but the results seem to be conclusive and show that the cushioning effect of the dust is very marked.



New Machine Mounted to Rotate Around Its Horizontal Axis.

The following tests have been made upon two limestones of very great difference in hardness:

(1) Both stones in the regular Deval test.

(2) Both stones with new type of chamber in a Deval frame.

(3) Both stones with new type of chamber with its axis horizontal and with an abrasive charge consisting of a small amount of 1-in. and ½-in. tempered steel balls.

(4) Both stones with new type of chamber with its axis horizontal and no abrasive agent.

(5) Both stones in a regular Deval test except that the stones and inside of cylinder were given a thorough dry cleaning after every 1,000 revolutions, thus reducing cushioning effect to a much smaller degree.

Table 1.—The results of tests of a hard and soft stone with the two types of abrasive chambers follow:

		Per cent wear		
	Kind of test.	Monon limestone	Bedford limestone	Ratio
1	Deval test regular	5.28	10.3	1.95
2	New type Deval frame	12.8	52.6	4.12
3	New type, horizontal with abrasive agent	12.8	37.6	2.94
4	New type, horizontal with no abrasive agent	12.3	35.25	2.87
5	Deval test with all dust removed after every 1,000 revolutions	10.7	25.8	2.41

In the new type of chamber practically all of the dust is removed as fast as formed. That this has a great effect is shown in items (1) and (2) in above table. In the case of the hard stone the removal of the dust caused only about 140 per cent increase in the per cent wear, but in the case of the soft stone it caused 410 per cent increase.

Bulletin 370 of the U. S. Office of Public Roads gives the per cent wear of 116 Indiana limestones. Of these the maximum per cent wear is 13.3 and the minimum 1.8. Using the values in the above table as a criterion, this range would have been at least from 68.0 per cent as a maximum to 4.3 as a minimum if the new type of abrasion chamber were used in a Deval frame, or from 45.5 to 4.2 if the new type of abrasion chamber were used rotating about its own horizontal axis without an abrasive charge.

Although more tests are needed to establish the facts, it would seem that the following conclusions can be drawn from the above tests:

To remove the dust in a testing machine of this kind is the correct principle and prevents the boosting of an inferior stone in comparison with a good one.

The new type gives a wider range of values for a given lot of stones and therefore better differentiation of quality.

The new type operating on a horizontal axis is a more simple and compact machine, and of cheaper construction.

RESURFACING OLD CONCRETE ROAD WITH 3 IN. OF CONCRETE.

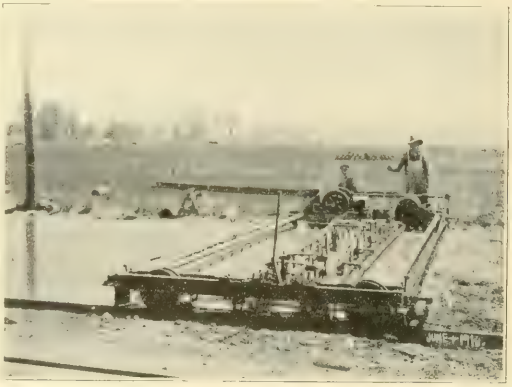
As an experiment the road commissioners of Wayne County, Michigan, last season resurfaced a section of concrete road with 3 in. of new concrete. The work is described in the last annual report of the commission, covering the period Oct. 1, 1915, to Sept. 30, 1916, from which the following notes are taken:

Grand River Road was selected for the experiment, because it was felt that it would receive the severest kind of test, on account of the heavy mixed traffic which uses this highway, and because the section selected was rough and uneven.

Sprinkling Tar on Moistened Roadway Immediately After Depositing Mixed Material for Wearing Surface.

This section of road was built in 1910 and is of a two-course construction. It is 6½ in. thick, 16 ft. wide—built on a crowned subgrade. The bottom course is a 1:2½:5 mix—using crushed limestone for the coarse aggregate, 4 in. thick. The wearing course is a 1:2:3 mix, 2½ in. thick—using crushed field stone, ranging in size from ¼ to 2½ in., for the coarse aggregate. It was put down in 25-ft. sections, with ¼-in. tar paper strips cutting entirely through the concrete. The surface was struck off with a template and was somewhat irregular in finish. The edges of the road were rounded off with about a 3-in. radius, a practice since abandoned. During the week of Aug. 17, 1912, 7,444 vehicles passed a given point on this road, and during the week of Sept. 18, 1912, 7,580 vehicles—by actual count—passed the same point, which is near where the road was resurfaced. Forty-plus per cent of these vehicles were horse drawn, the balance being motor driven. This territory has been built up rapidly since the above traffic count was taken, and an actual count at the present time would undoubtedly show a very material increase in the number of vehicles passing a given point. To better accommodate this increased traffic it was decided to widen the road to 20 ft. In order to do this the rounded edge was broken off and concrete added on each side of the old road to bring it out to the required width. A 1:2:4 mix, 6 in. deep, of washed and screened pebbles and washed and screened sand—of the same quality as provided in the standard specifications—was used.

All the Tarvia surfacing and filling used to cover the cracks was removed. The cracks and holes were then filled with concrete to make an even surface 20 ft. wide. The expansion joints—as steel protection plates were not used—were mostly worn down. Where the joint was spalled to a considerable extent the old concrete was broken away sufficiently to give a bond for new concrete on both sides of the joint. Expansion felt was then placed and the whole surface brought up to an even grade. On the top layer of this base was placed a 3-in. layer of 1:1½:2½ concrete—using Marquette, Mich., trap rock, graded in size from ¼ in. to 1 in., for the coarse aggregate, and washed and screened bank sand for the fine aggrate. The surface in no place is less than 3 in. thick—reinforced with No. 26 triangular mesh wire. It was not attempted to bond the top course to the old road with a rigid bond. The surface of the old concrete was first sprinkled with water, after which a mixture of Tarvia A and Tarvia X was sprinkled on, hot, with an ordinary sprinkling can, immediately before placing the new wearing surface. The Tarvia, falling on the moist concrete, spread in a very thin layer and was immediately chilled, thus forming an even coat over the old surface. The expansion joints in this top course coincide exactly with the expansion joints in the bottom course. A piece of wood 3 in. by 4 in. by 20 ft. long was laid over the old joint and the concrete deposited as though no joint was to be made. A Baker automatic finishing machine was used to finish the surface. Afterward this piece of wood was removed and armor plates suspended from installing bars with expansion felt were set into place on the side forms—the felt of the new joint meeting the tar paper of the base joint. The commission believes this method to be better than pouring the top course directly onto the bottom one, as a slight movement, due to difference of expansion or heaving, would result in cracks to the top course if they were rigidly bonded together. The Tarvia, although very thinly spread, permits a slight movement of each course without interfering with the other.


Finishing 20-Ft. Resurfacing Job with Automatic Finishing Machine.

Before approving of this type of construction small slabs of concrete were made, a coat of Tarvia put on top and another course of concrete deposited. It was found not only impossible to separate these two layers, but a blow on the upper—sufficient to crack the top course—would also crack the bottom one. The road was covered in the regulation manner to hold the moisture and sprinkled daily for two weeks. Traffic was permitted to use the road 25 days after the last concrete was placed.

The cost of this work, $15,573.67, is stated to be high, due to conditions at time work was undertaken.

5½ YEARS' WORK OF WISCONSIN HIGHWAY COMMISSION.

On Jan. 1, 1917, the State Highway Commission of Wisconsin completed 5½ years of existence, and the supervision of 5 years of actual construction under the State aid law. The first construction under this law was in 1912. The following table shows the number of miles of road and number of bridges built each year under the supervisors of the Commission:

	1912	1913	1914	1915	1916
Roads—					
Hard surfaced, miles	235	414	649	626	641
Temporarily surfaced, miles	2	18	51	38	103
Graded and drained, miles	229	483	601	559	486
Total, miles	449	888	1,220	1,130	1,159
Bridges—					
State aid, number	115	151	294	280	352
County aid, number	190	276	341	339	433

In 1912 there was expended for State aid road and bridge construction $1,047,899; in 1913, $2,473,528; in 1914, $4,240,760; in 1915, $4,134,830, and in 1916 $4,215,182; giving as the total expenditure for the five years of operation the sum of $16,112,202. Of the total expenditures in the five years 6.5 per cent were made in 1912; 15.4 per cent in 1913; 26.4 per cent in 1914; 25.7 per cent in 1915; and 26.0 per cent in 1916. All of the above figures are confined exclusively to State aid road and bridge construction supervised by the State Highway Commission.

Omitting the expenditures for State aid bridge construction, the total expenditures for all classes of road construction in the five years was $14,631,824. The total road construction was 4,846 miles. Therefore, the average cost per mile for all State aid road construction during the five-year period has been $3,019. These figures include the construction in Milwaukee County. In order to obtain a fair average of the construction cost in the average Wisconsin County it is best to subtract the construction cost ($2,378,936) and the mileage (132.71) of the work done in Milwaukee County, inasmuch as this work, due to especial conditions not prevailing in any other county, consists of wide surfaces of far more expensive character than will generally be built. With these subtractions the total road expenditures become $12,252,888 and the mileage 4,713.48. Consequently, the average cost of State road construction outside of Milwaukee County has been $2,599 per mile.

In addition to the above amount of State aid work there has been planned and supervised by the Commission's bridge department the construction of 1,627 county aid bridges paid for by the towns and counties, the cost of which was about $1,780,683. The total of the miscellaneous construction covered is $332,200.

A summing up of the amounts expended on all work supervised by the Wisconsin Highway Commission gives: State aid road construction, $14,631,824; State aid bridge construction, $1,480,377; county aid bridge construction, $1,780,683; miscellaneous construction, $332,200; giving as the total cost of the actual construction planned and supervised the sum of $18,225,085.

The State expenditures chargeable to the supervising work of the Commission for the five fiscal years ending June 30, 1916, were $339,189. The estimated expenditures from July 1, 1916, to Dec. 30, 1916, are $32,000, giving a total expenditure for the 5½ years of operation of $371,189.

Dividing the work performed ($18,225,085) into the cost of operation of the State Highway Commission ($371,189) it is found that the cost of State supervision averaged 2.036 per cent of the cost of the work supervised.

Up to Sept. 1, 1915, the engineering expenses of the Wisconsin Highway Commission covered not only the supervision of the work, but the preparation of all plans for road and bridge construction. Since that date the principal part of the cost of preparing plans for road construction has been charged to the counties under an amendment made to the State aid law by the Legislature of 1915. The cost of all surveys and the preparation of plans for all classes of bridges has been paid from the outset out of the Commission's funds and no change has been made in this regard.

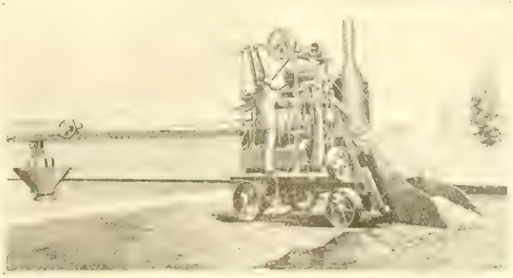
The above summary of the work and the above estimates of the supervision cost makes no allowance whatever for the miscellaneous activities of the Commission, such as the publication of reports, bulletins and pamphlets; news letters; road schools; exhibits; attendance at public meetings; county board meetings; farmers' institutes; investigations of the county highway systems; letters of advice to road officials and other public officials and the many other minor things which must be attended to in conducting the highway business of a State. In brief, the percentage of the supervision above (2.036 per cent) is the percentage of supervision if the total cost of the Commission's operations is charged exclusively to construction. The cost of State supervision has decreased each year until in 1916 the cost of supervision is only 1.308 per cent of the work performed.

The cost of supervision by the counties; the salaries and expenses of the County Highway Commissioners and their necessary assistants up to Jan. 1, 1916, averaged about 2.81 per cent of the cost of the construction and maintenance supervised by the County Highway Commissioners. If this is added to the 2.036 per cent for the cost of State supervision, the total cost of all supervision on State highway construction equals 4.846 per cent.

Commencing Jan. 1, 1916, or a little before, there has been added to the cost of county supervision the cost of the preparation of all road plans and the cost of the county State road and bridge committees created by the Legislature of 1915. These two items for the State will probably total $68,400, giving an additional percentage for the cost of county supervision in 1916 above that of previous years of about 1.448 per cent. This is compensated partly by the reduction of 0.439 per cent in the percentage of the supervision by the State Highway Commission, due to the transfer of the cost of the survey and plans to the counties and possibly by a slight reduction in the cost of supervision by the County Highway Commissioners, though this last item probably remains about constant.

"STANDARD" SPECIAL STREET PAVER.

A paving mixer having a number of new features has been placed in the market recently by the Standard Scale & Supply Co., Pittsburgh, Pa. The mixer is medium sized and has a capacity of 11 cu. ft. of unmixed or 9 cu. ft. of mixed material per batch. It is equipped with skip loader, steam engine and boiler and either a sectional distributing spout or a distributing boom and bucket. The bucket has a bottom discharge, which while delivering also spreads the concrete so as to materially lessen the hand work of leveling. The boom has an effective length of 20 ft., and swings horizontally through one complete half circle. All movements including the opening and closing of the discharge are controlled from the operator's platform. The machine is designed to equalize the weight on the four ground wheels.



"Standard" Special Street Paver.

Comparative Costs of Belt Finishing and Hand Floating for Concrete Roads.—The following comparative costs on the two methods of finishing concrete roads are taken from the January Concrete Highway Magazine. The figures are from records kept on a job in Kenton County, Kentucky.

By hand float finish, first-class job—	
Finishers, 12 hours, at $0.50	$ 6.00
Assistant finisher, 12 hours, at $0.35	4.20
Cost per day	$10.20
Average cost per sq. yd., 1.7 ct.	
By belt finish, first-class job—	
Finishers, 10 hours, at $0.35	$ 3.50
Assistant finisher, 8 hours, at $0.25	2.00
Cost per day	$ 5.50
Average cost per sq. yd., 0.9 ct.	

Surface Covered by Various Sized Loads of Stone.—The following table taken from the recently issued Third Biennial Report of the Wisconsin Highway Commission shows the number of linear feet of 9-ft. road a load of a given size should cover for various loose depths:

Weight of load			Loose depth in inches			
Granite.	Limestone.	Size of load. Cu. yd.	3 in. Ft.	4 in. Ft.	5 in. Ft.	6 in. Ft.
2,800	2,500	1	12	9	7.2	6
3,500	3,125	1¼	15	11.25	9	7.5
4,200	3,750	1½	18	13.5	10.8	9
4,900	4,375	1¾	21	15.75	12.6	10.5
5,600	5,000	2	24	18	14.4	12
6,300	5,625	2¼	27	20.25	16.2	13.5
7,000	6,250	2½	30	22.5	18	15
7,700	6,875	2¾	33	24.75	19.8	16.5
8,400	7,500	3	36	27	21.6	18

State Reward Roads in Michigan.—The State of Michigan began to improve its roads under the state reward plan in 1906 (the 1906 fiscal year began July 1, 1905). The progress in this work up to the end of 1914 is summarized as follows in the recently issued biennial report of Frank F. Rogers, State Highway Commissioner:

Year	Miles built.	Total fund	Trunk line fund.	Departmental expenses.
1906	18.00	$ 30,000	....	$10,000
1907	64.25	60,000		10,000
1908	96.50	110,000		10,000
1909	161.00	160,000		10,000
1910	204.50	150,000		10,000
1911	305.25	150,000		10,000
1912	382.75	245,000		10,000
1913	523.00	383,000		10,000
1914	682.32	650,000	$200,000	18,000
Totals	2,437.57	$1,938,000	$200,000	$98,000

During the fiscal years 1915 and 1916, 1,851½ miles of road were accepted for state reward, making a total of 4,289 miles to date—an increase of 75 per cent in the total improved road mileage of the State. State reward was paid on only 1,503¼ miles, 348¼ miles being accepted but not rewarded because of lack of funds. During the same time 37 trunk line bridges were completed by the state, and the construction of 14 bridges was started. During the two fiscal years a total of 967¾ miles of gravel roads, constituting 65 per cent of the total mileage built during the same period, were constructed. This brings the total number of miles of gravel road accepted for state reward up to 2,538 miles or 60 per cent of all roads accepted.

PERSONALS.

W. Owen Washington, C. E., Assoc. Mem. Am. Soc. C. E., of the firm of Whiteaker & Washington, San Antonio, Texas, has been commissioned as captain in the Engineer Officers' Reserve Corps, United States Army.

F. H. Frankland, formerly engineer of bridges for Calcasieu Parish, Louisiana, has become associated with Waddell & Son, consulting bridge engineers, Kansas City, Mo., and will be in charge of the branch office opened recently at 165 Broadway, New York City.

P. W. Clancy has been appointed Nebraska representative of the Kansas City office of the Portland Cement Association. He was formerly engaged in municipal work and as resident engineer of construction for the Canadian Northern Railway and Union Pacific Railway.

W. R. D. Hall, statistician of the Pennsylvania State Highway Department, has resigned his position, having been appointed manager of the Publicity Bureau of the Philadelphia Chamber of Commerce. Mr. Hall has been with the State Highway Department since October, 1912.

H. S. Owen, formerly principal assistant to the chief engineer of construction, streets and sewers, of St. Louis, Mo., has accepted the position of field engineer for the Kansas City office of the Portland Cement Association. His new work will be confined to Eastern Missouri, with headquarters in St. Louis.

C. I. Felps has been appointed field engineer for the Kansas City office of the Portland Cement Association, with headquarters at Wichita, Kans. Mr. Felps was formerly connected with the Highway Department of Kansas and more recently with the bridge department of the Kansas City Terminal Railway Co.

The W. S. Barstow Management Association, 50 Pine street, New York, has been incorporated and will supervise the management of all public utility properties controlled by The General Gas & Electric Co., The Eastern Power & Light Corporation and W. S. Barstow & Co., Inc. E. L. West has been elected president of the new corporation.

William H. Corddry, formerly with the W. J. Sherman Co. of Toledo, O., on dam construction, and formerly assistant engineer, Baltimore Sewerage Commission, has joined the staff of Gannett, Seelye & Fleming, as assistant engineer in connection with the Mill Creek flood control, Erie, Pa., and Erie sewage treatment investigation. He is a graduate of Lehigh University, class of 1911.

The Central Construction Corporation of Harrisburg, Pa., has acquired the business and property of the Central Construction & Supply Co. and will engage in the design and construction of buildings, manufacturing plants, power plants, railroad terminals and construction projects generally. The officers are George B. Tripp, president, formerly vice-president United Gas & Electric Engineering Corporation; Joseph H. O'Brien, vice-president, formerly managing engineer Westinghouse, Church, Kerr & Co., and Charles E. Covert, secretary and treasurer, formerly treasurer Central Construction & Supply Co.

Paul P. Stewart, chief engineer and treasurer of the Ketler-Elliott Erection Co., Chicago, has been appointed national director of the American Association of Engineers to fill the unexpired term of A. H. Krom, who resigned to become general manager of the association. Mr. Stewart is a well-known Chicago engineer, at present a member of the above-mentioned firm. He is an '02 graduate of Yale and has been connected with the U. S. Steel Corporation for many years, where he had charge of design and most of the construction work at Gary. He was formerly professor of structural engineering at Ohio Northern University.

The Ohio State Association of Contractors has been organized with a charter membership of about 200. The organization will have state headquarters at Columbus, O., in charge of a secretary-treasurer. H. E. Culbertson of Cleveland, O., has been chosen president, William Graham of Columbus, vice-president, and William E. Minshall of East Cleveland has been made general counsel. The secretary-treasurer has not been selected. The directors are: A. G. Pugh and J. T. Adams, Columbus; Thomas Bently and L. H. Hawblitz, Toledo; D. Y. Swatty, Cleveland; William Adams, Zanesville; William Fink, Dayton; H. S. Illiff, London; R. G. Tomlinson, Chillicothe, and D. W. McGrath, Columbus.

The Universal Portland Cement Co. announces the succession of R. L. Slocum to the position of assistant superintendent of Mill No. 5 at Universal, Pa., made vacant by the death of R. F. Knoth in January of this year. Mr. Slocum was born at Homestead, Pa., graduated from the Pennsylvania State College in 1905, spent two years in construction for the Homestead Steel Works and began work in the spring of 1907 for the Universal Portland Cement Co., in charge of building construction and installation of machinery at Universal, Pa. Since the completion of the plant he has been responsible for extensions, repairs and in part for operation. His title is the same as that held since 1911, but he is now in charge of plant operation and management under E. D. Barry, superintendent.

W. A. Van Duzer, assistant engineer of the Pennsylvania State Highway Department, in charge of District No. 12, comprising the counties of Lackawanna, Monroe, Pike, Wyoming, Wayne and Susquehanna, has resigned his position with the department to engage in private business in another state. W. H. Bircher of Scranton, superintendent of Lackawanna and Wayne Counties, has been promoted to be acting assistant engineer in charge of District No. 12. Mr. Bircher has been with the State Highway Department 7½ years in various engineering capacities. To fill the vacancy caused by the promotion of Mr. Bircher, W. J. Devereaux, also of Scranton, now chief of construction in this district, has been appointed superintendent of Lackawanna and Wayne Counties. Mr. Devereaux has been with the department 6 years. Edwin Bytheway, superintendent of Lehigh and Northampton Counties, has resigned his position because of illness in his family and the vacancy thus created has been filled by the appointment of H. G. Fenstermacher of Allentown. Mr. Fenstermacher has been with the department for 5½ years in various engineering capacities.

The first convention of the Southwestern Society of Engineers will be held March 8 at the Hotel Sheldon, El Paso, Tex. The first steps for the formation of the society were taken on Dec. 27, when committees were appointed to draw up a constitution and make arrangements for the convention. The society will cover West Texas, New Mexico and Arizona. In these sections there are around 800 to 1,000 men available for membership. The constitution committee has practically completed its work and extracts from the proposed constitution are as follows: First—The object shall be the professional improvement of its members; the encouragement of social intercourse among engineers; the advancement of engineering knowledge, education and practice, and the maintenance of a high professional standard among its members. Second—It was thought best to provide for three classes of membership, namely, the full member, which is an engineer not less than 27 years of age and who has been in active practice in his profession for at least 6 years; the associate or junior member, who shall not be less than 18 or more than 30 years of age and who shall be actively practicing or a student or graduate of a recognized technical school; the affiliated, who shall be persons interested in the objects of the society and who by practical experience qualify them to co-operate with engineers, but who are not professional engineers. Third—The constitution provides for an initiation fee of $5 for members, for associates $3 and for affiliated $2. The annual dues for members are $3 and for associates and affiliated $2. Fourth—The constitution provides for semi-annual conventions, the first on the third Wednesday in October, to be held in El Paso, Tex., and the second to be held at such time and place as the board of directors may determine. The committee on membership consists of: J. F. Woodyards, Jr., El Paso, Tex.; S. O. Andros, Albuquerque, N. M.; G. M. Butler, Tucson, Ariz.; A. F. Barnes, State College, N. M.

INDUSTRIAL NOTES.

Cass Kennicott has become associated with The Permutit Co., New York City, and will be in charge of the company's Chicago office, 208 South La Salle street.

Stanley B. Bates, Assoc. M. Am. Soc. C. E., formerly editor and manager of The Contractor, has become associated with the Lee Loader & Body Co., Chicago, manufacturer of the Lee line of loaders, motor truck bodies and other equipment used in the handling and hauling of loose materials. As a civil engineer Mr. Bates has made a special study of haulage problems, particularly those of the contractor, and is author of many articles on the subject. He will have charge of the sales department.

At the annual meeting of the board of directors of the Detroit Steel Products Co., Detroit, Mich., a cash dividend of 10 per cent was declared on the common stock besides the regular annual dividend of 7 per cent. These dividends were, in addition to liberal appropriations for new buildings and equipment made necessary by increased demand for the company's products. The following officers and directors have been elected for the ensuing year: President, J. G. Rumney; vice-president, R. S. Drummond; secretary, H. F. Wardwell; treasurer, E. R. Ailes; board of directors, J. G. Rumney, R. S. Drummond, Walter S. Russel, Henry Russel, Leo M. Butzel, Mason P. Rumney, all of Detroit, Mich., and H. Otto Meyer of Clinton, Iowa.

Water Works and Hydraulic Issue
of

Engineering and Contracting

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HAS THE PIKE'S PEAK OF WAR PRICES BEEN REACHED?

Every large modern war has caused a rise of prices in the belligerent countries. Often the effects have extended to countries far removed from the area of conflict. The greatest of all wars—the present one—has effected the greatest of price changes, and had it not been for government price fixing in the belligerent countries the rises in prices would have been even more extreme.

In America we are concerned at present over the question as to the probable fall or rise of prices during the coming year. Much construction work is being held up until material prices drop and labor ceases to be scarce. Has the Pike's Peak of war prices been surmounted, and are we about to descend into the valley beyond? An answer to this question will be of great importance to many engineers and contractors.

All economists are agreed that prices rise when there is increase in the metal money and "credit money" seeking exchange for "goods," or when there is decrease in the quantity of "goods" seeking exchange for money. In war times both these conditions prevail, for "credit money" increases through government action, and the production of "goods," seeking exchange decreases through the removal of industrial works to the battlefields. In America we have had the greatest gold flood during the last two years in all our history. Even more important in raising prices has been the flood of "credit money." Abnormally small crops and congestion of railways have reduced the available quantity of "goods," and have thus aided the general rise of prices in this country.

A review of these facts is essential before prognosticating as to the future course of prices. It is also necessary to consider what psychological effects the high prices of the present will have upon producers and investors. To begin with, we may be certain that the glittering, golden bait of dollar corn and two-dollar wheat will cause most farmers to swallow the "bait, hook, line and sinker," and to come back so eagerly for more that the bait will presently begin to be withdrawn. In other words, there is no doubt that the year 1917 will be a year of unprecedented planting of almost every kind of crop, and, barring adverse climatic conditions, this will be a "banner year" for foodstuff production. This alone would tend to produce a general lowering of the price level during 1917, but there will be other potent forces working toward a drop.

When England recently notified American manufacturers of shells and shrapnel that they must finish all deliveries by the end of March, and that no further contracts for such munitions will be made, the economist's ear heard the clang of the gong that announces this to be the last lap of the war—and this without regard to who will be the victor. Immediately there followed such significant incidents as the discharge of 1,800 men working for the Baldwin Locomotive Co. on munitions, and the announced reduction in the dividend rate of the du Pont Powder Co.

Hard upon the heels of these incidents came the definite statement from government officials in England that imports would be greatly reduced, both as a matter of necessary economy and because the British Empire has at last so organized its industries as to need little outside assistance. This points unmistakably to a very marked reduction in the shipment of American goods to Europe, entirely aside from any forced curtailment as a result of submarine warfare.

So now we face simultaneously an increased production of foodstuffs in America and a decreased demand abroad for many of our goods. The congestion of our railways will rapidly decrease—is already decreasing—so that a further drop in prices will follow from this change.

Still, all the metal money that America now holds will remain, and will probably increase for a time. Will this condition not serve to hold up prices? Metal money forms only one-fifth of the total "real money" normally in "circulation," for bank "credits" based on metal money are many fold the volume of metal money and serve every purpose of exchange. Let there be started a well-marked fall of prices—as from the curtailment of foreign demand for goods—and "credit money" automatically begins to shrink in volume. This merely means that manufacturers and merchants, seeing a declining market, hesitate to engage in so large a volume of production and storage of "goods" as formerly. They thus cease themselves to "demand" so many "goods" from one another and from the producers of "raw materials." The circle of reduced "demand" rapidly widens, some laborers are discharged, and "demand"—i. e., money in search of goods—decreases in geometric proportion.

Many signs already point distinctly toward a period of declining prices in America. Even our own entrance into the war is unlikely to change materially the general trend of price reduction.

Will a marked fall in prices affect civil engineers and contractors unfavorably? We think not. Indeed, we look for a favorable effect. Most civil engineers are employed on public works or works of a semi-public nature, like railways and other "public utilities." Capital for works of these sorts is usually raised by the sale of bonds. But the high rates of interest that have prevailed since the war began have often deterred both public officials and the managers of "public utilities" from entering upon large construction programs. Higher interest rates always accompany a general rise of prices. With a fall in prices, lower interest rates will occur, and this alone will stimulate the marketing of bonds for public and semi-public enterprises. A further stimulus will be the lower prices for materials.

If the drop in prices were consequent upon a great shock to credits in general—a "panic"—of course there would be no reason for expecting a revival of public or semi-public construction work. In fact, a great decrease in such work would result. But we are neither entering upon nor emerging from a "panic." General confidence is not shaken, capital is abundant and will be available at low interest rates. Profits in many industries have been large, and capitalists are eager for continued action—a chance to "sit in" at the great game. All conditions coexist, we believe, for a progressively prosperous time for civil engineers and contractors.

THE NUMBERLESS USES TO WHICH WATER MAY BE PUT IN EVERY CITY.

Engineers and waterworks managers in America have come to entertain an almost reverential respect for a city that is able to hold its water consumption below 100 gal. per capita. This old "100 gal. per capita" is in danger of becoming an ideal, analagous to "100 per cent efficiency," yet with no real reason back of it, further than that it is possible to serve the average American city with no more than "100 gal. per capita," and satisfy everyone.

In England, however, the corresponding deal is about "50 gal. per capita." Does that prove the English to be twice as efficient as the American waterwork's manager? If not, what does it prove? Simply this, that where the average income of citizens is small their necessities force them to conserve it, and contrariwise when the income is large. That Americans waste a vast amount of water because it is not metered is known to all hydraulic engineers, but it does not follow that our ideal should be the ultimate reduction in water consumption per capita. Rather our ideal should be a reduction in the per capita waste and an increase in the per capita use of water in economic ways and to increase the health and pleasure of our people. It is quite conceivable that such a use may lead eventually to an average water consumption of 250 gal. per capita, or more. We Americans use four times as much electricity per capita as do the English or French. Yet who charges us with undue wastefulness in the consumption of electricity? No one, for electricity is almost universally sold as a metered "commodity," making it distinctly and evidently unprofitable to the individual who wastes it.

"But," it will be urged, "electricity has many possible uses whereas water has but few. Electricity, therefore, can be marketed intensively and extensively. Water can not." Is this last conclusion justified even if it is conceded that electricity has more fields of usefulness than water? We doubt it.

The sale of any product is not altogether dependent upon the number of uses to which it may be put, but it is dependent upon the understanding that the public has of its relative worth—upon the educational advertising that it has received. Cameras have relatively few uses, but the sales of cameras have become enormous through publicity. The same holds of innumerable things. Of all "public utilities," water has gained the least in "popularity" and sale, largely because it has not been given proper publicity.

The uses of city water? Are they so few after all? Not to mention the everday uses for bathing, washing, cooking and drinking, there are innumerable commercial uses. Possibly none of these uses can be greatly increased through educational publicity, although we doubt that. If water were sold by meter, would it not pay to induce owners and architects to install shower baths in every bathroom, and to encourage the use of the shower by every person, morning and night? Surely there would be no greater difficulty in accomplishing such an education than there has been in showing the public that "electric toasters," "irons," "vacuum cleaners" and "washing machines" are necessary domestic instruments.

But here we waterworks men sit, dead to the evidence of the success of educational publicity on every side of us, excusing our inactivity on the ground that "our business is radically different from others." What of our opportunity to sell water for backyard and vacant lot irrigation, mentioned in another column? What of the "respiratory organ disease" that we might prevent by the extensive daily flushing of our streets? Is Seattle, with its astonishingly low mortality (8 per 1,000), no object lesson in the effectiveness of street flushing from city hydrants and from frequent rains? What of snow removal by scraping into sewer manholes and washing away with floods of water? What of the possible remodeling of our sewer systems to facilitate the more extensive use of water for carrying away dirt, refuse, and even ashes? Who that has seen the hydraulic miner and the hydraulic dredger at work can doubt the efficiency of water as a carrier of materials heavier than water?

Why, the possible uses of water are almost numberless, yet the actual use to which water is now put in our cities is so limited as to make us exclaim in wonder at the general ignorance. Who is to blame for this ignorance? We engineers, we waterworks managers, and we publishers of technical periodicals and books—all are in the same half-scuttled skiff, drifting without paddling, even though we have the paddles and know how to use them.

We must entirely change our attitude of complaisance and inaction. There are countless uses to which city water may be profitably put. Let us search them out and show the public what they are.

WILL UNIVERSAL MILITARY SERVICE BE ECONOMIC?

In our last issue, Major P. S. Bond, Corps of Engineers, U. S. Army, answers this question with an emphatic yes. In our issue of Feb. 21 we had questioned the economy of universal military service compared with a relatively small standing army and a large navy, and we had pointed out that the subject is not one to be settled by mere verbal debate on theories, but rather by comparative cost data.

Major Bond, we are glad to note, agrees with us on this stand, but he points out that the relative profits as well as the relative costs must be weighed. Without question he is right. It had seemed to us that if an industrial training involving proper physical exercise and discipline, were substituted for a military training, the profit would be even greater than from a purely military training; hence we did not raise the question of profits. Now that it has been raised, it seems pertinent to ask what definite statistics are available, for without statistics the question of the profitableness of different forms of training can never be satisfactorily answered.

It is quite possible, as Major Bond says, that our estimate of 6 per cent annual depreciation of battleships is inadequate. In estimating depreciation annuities, it should be assumed that an annuity will draw interest at the prevailing rate of interest. A 6 per cent depreciation annuity compounded at 4 per cent will amount to the principal in about 13 years. Such statistics as were available to us indicated that the "effective life" of a battleship —not its full "natural life"—has averaged 10 to 15 years. This, however, is but a detail of our argument as Major Bond has noted. The crux of the matter is: What are the relative costs and the relative profits of different systems of national defense and citizenship training?

Military training is conceded to be beneficial to individuals and to society in so far as its effects on health and discipline are concerned, and these are two very important matters. Fourteen years ago the writer published an editorial in Engineering News, entitled "Should Civil Engineering Schools Be Modeled After West Point?" The writer believed then and still believes that, with relatively slight changes, the training at West Point is superior as a training for civil engineers to that to be had in most civil engineering colleges. The following quotations from that editorial may be of interest in this connection:

> Engineers will find in West Point a model well worthy of consideration in virtue of what is not taught (as well as in virtue of what is taught) there. They will not find students there spending several hours a day for several weeks working on problems in chimney design, as is the case at one of our engineering colleges. They will not find students bending over drawing boards for weeks designing every type of bridge truss, as at another college. What they will find is: First, coordination of the courses, so as to give to each subject its due apportionment of time; second, disciplinary training that tends to make leaders of men; third, physical training that insures a long life of usefulness (and adds to happiness); fourth, moral training that puts honor above every other consideration of life.

The editor believes enthusiastically in physical, moral and mental training for all men. He questions only the relative effectiveness of different types of training. He is not at all certain that universal military training is the best type of training even for health and discipline. But rather than no training, he would unhesitatingly support a system of universal military service for young men.

Coming back to the reasoning involved in solving this entire problem, we find it essential to have statistical results. Where are they? Debate may fare merrily on till doom, or it may suddenly end through the passage of a bill for universal military service—and still we shall not know the true economic answer until we secure the necessary economic data.

AN AMERICAN ENGINEER MADE FAMOUS BY THE WAR.

Herbert C. Hoover, mining engineer and graduate of the University of California, has so effectively managed the work of the Commission for Relief in Belgium as to become the focal point of every eye in Christendom. Through his hands have passed a quarter of a billion dollars for relief in Belgium and France. "In Europe," says Prof. A. E. Taylor, "Hoover is regarded as one of the unique creations of the war. Before the war he was one of the great mining engineers and efficiency experts in the world."

Prof. Taylor adds that Mr. Hoover is "an organizer par excellence, is saturated with enthusiasm and does not know the word fail." Such a man has every great executive been—"saturated with enthusiasm." But to be great as an executive a person must possess more than enthusiasm. That is the driving steam, it is true, but there must be a suitable mechanism to be driven. Looking upon the more visible qualities of a successful manager like Mr. Hoover, the world is apt to forget the less visible qualities, the habits and "training" that have made the mental engine fit to respond under the pressure of great purposes. That Mr. Hoover was a highly trained engineer before he succeeded so strikingly in his unique position is a fact not lightly to be overlooked. His "insight and power," and even his "idealism," of which Prof. Taylor speaks, are doubtless as much dependent on his education and training as on his inherited character.

Those who know little about science and less about scientific men are prone to regard the investigation and application of science as being processes that rob the mind of some of its idealism. They look to the teacher of ethics, the poet, the artist and the musician to find the highest types of idealists; for are not the "dreamers" the only true philosophers of goodness and beauty? They fail to perceive that beauty is not resident alone in pigments and rhythms and that goodness does not spring solely from a study of goodness, nor yet from talk about its virtues.

There is beauty in the very orderliness of natural phenomena, and magnificence in the amazing co-ordination of scientific laws. Here, if anywhere, truth is to be found by the seeker. Here the vastness of time and the brevity of human life stand in such mighty contrast as to make the scientific man exclaim: "What availeth my own fleeting profit if there goeth not with it a lasting profit to my fellow men?"

"EVERY MAN HIS OWN TRUCK FARMER" AND THE SELLING OF CITY WATER FOR IRRIGATION.

Eight months ago we began urging upon waterworks managers the importance of investigating the possibilities of using city water for irrigating "back yards" and vacant lots. Events that have transpired since then serve to confirm our opinion that there is abundant reason for believing that many residents of towns and cities can be induced to become "their own truck farmers," as the Philadelphia "Public Ledger" puts it. We quote from a recent editorial in that paper:

> With the high prices at present prevailing for vegetables, few will take issue with James H. Dix, superintendent of the Vacant Lots Association, who says that $500.000 could be saved by our citizens by raising vegetables on the vacant land within the city limits. On the 100 acres which the Vacant Lots Association has at its disposal crops to the value of $30,000 were produced last summer. That is an average yield of $300 per acre.
>
> Mayor Oberholser, of Oklahoma City, promised last spring to award an automobile to the boy or girl who raised and sold the largest amount of garden truck on a tract 25 by 140 ft. The prize winner, a 15-year-old lad, sold his output for $102.82. That works out at $1,250 an acre. A farmer boy in Oklahoma County was given a little creek-bottom land by his father. It had been in potatoes the previous season and was overgrown with weeds. The lad plowed it to a depth of eight inches, harrowed it three times, and made it yield more than 100 bushels of corn to the acre.
>
> The moral is plain: To bring the prices down, let every householder who is able to gain access thereto cultivate his own garden, large or small, and astonish himself and the community with the lucrative and exhilarating proceeds of his husbandry.

That "the moral is plain," we concede, but it would be plainer and more likely to be acted upon were every waterworks manager to encourage the use of water for irrigation. The encouragement should consist: First, in a sliding scale of meter rates that would promote the use—not the waste—of comparatively large quantities of water for irrigation; and, second, in publicity through the daily press, the schools and otherwise. Publicity is not the lesser of these two forms of "encouragement," yet publicity is about the last thing that the average waterworks manager thinks of, for he is accustomed to regard it as "out of his line."

We believe that publicity to a campaign for city water consumption for irrigation will be gladly given by most city papers. The present high price of garden truck offers a splendid chance to arrest public attention. Let the advertising slogans be:

Enjoy your own peppery radishes and juicy berries.
A nickle of seed makes a muckle of satisfaction.
Insure your crop by irrigation.
Stop wasting water; use it!
A meter makes a man thrifty, and thrift is first cousin to wealth.

As we have previously and often pointed out, general metering of water will so greatly curtail waste that abundant water will be made available for irrigation by gardens. Following the practice of electric companies that sell a small quantity of "juice" at 8 ct. a kilowatt hour and a large quantity at 1 ct. a k. w. h., water when metered should be sold on a sliding scale rate.

A CRITICISM OF DEFINITIONS OF ECONOMIC TERMS AND "LOGIC FOR ENGINEERS."

To the Editor: Your discussions of logic and economic terms in your Jan. 31 number appear to me more novel than convincing.

When one starts out to rewrite a line of work which the greatest intellects of the world have developed he must be very sure of his new position and overwhelming in his statement of the case.

I take it that "value" is "the measure of desire to possess an article." "Price" is "the expression of value in terms of some medium of exchange." It may be expressed in money, bushels of wheat, ounces of fine gold, or any other substance. As a matter of fact, contracts are in existence in which the price is expressed in the three items above named, rather than in money.

Like the ambition of every college professor to write a book, many writers, especially in economics, sociology, etc., delight to redefine and coin new terms. This leads to confusion of ideas and prolixity of writing to explain and defend such terms.

In your paragraph, "Value Defined," you speak of "intrinsic worth." I believe there is no such thing. Wheat, for instance, has no intrinsic worth—that is, worth because of the fact that it exists and is wheat.

Under "value defined" and "cost defined" you proceed to build up a lot of new terms and definitions. It does not add to clarity or precision of thought to group under the new term, "sacrifice cost," a lot of unrelated items. Under "profit defined" you say "profit includes sacrifice cost." Sound English and pure economics or correct reasoning cannot make "profit" mean or include "cost."

Truly, Appelles said to the shoemaker in Athens 2,000 years ago: "Shoemaker, stick to your shoes," when he attempted a criticism of Appelles' painting.

Your paper as a publisher of engineering and engineering cost data is valuable and worth while.

Victor Windett,
Civil and Mechanical Engineer.

Chicago, Ill., Feb. 27, 1917.

[Let us consider these criticisms in an inverse order, taking the last one first. Can "profit" and "cost" never be used so as to be or appear to be "mutually inclusive" terms? If not, then a merchant's profit could not be a part of a customer's cost. Profit is a term that implies two parties to a transaction, and what is profit to one becomes cost to the other.

"Sacrifice cost" is a term used to designate various true debits that are not always charged in a ledger account against a given operation or product. Conspicuous among these is a true debit of the account to the owner for his services.

The U. S. Department of Agriculture has in recent years been urging farmers to include the market value of their own services and that of their families as part of the cost of farm products. Hitherto this has not been a common method of accounting among farmers, but that there is much to commend it is almost self-evident. Now, if Farmer Jones follows this new practice and charges up his own services at $3 a day, while Farmer Smith adheres to the old practice of charging nothing for his own services, their respective "profits" will differ. Farmer Jones' "profit" will exclude the "sacrifice cost" of his own services, whereas Farmer Smith's "profit" will include the "sacrifice cost" of his own services. Our discussion of these terms was purposely aimed to bring out this sort of discussion and to show that "profit" is still defined in various manners. The later editorial in our issue of March 7 will have served to indicate the wide variations in the meaning of the word "cost."

Perhaps "sacrifice cost" is an ill-chosen term. Possibly "sacrifice value" or some other term would be better. But our correspondent fails to make a sound argument against its use on the ground that it seems incongruous that a "cost" as viewed by one man may be viewed as a "profit" by another man. Equally indefensible is his criticism that "sacrifice cost" includes "a lot of unrelated terms." The lot of "unrelated terms" to which he refers consists of charges for different things—risk insurance, supervisory wages, etc.—it is true, but they are all related to one another in this respect, that they do not appear as cost charges on the ledger of Farmer Smith, for example, whereas they do so appear on the ledger of Farmer Jones. To Farmer Jones, then, these various possible charges all have one characteristic in common; they are debits deferred or payments foregone which he expects to collect as "profits."

We have already indicated by implication that this distinction between these economic terms is not a mere verbal quibble, for it goes to the very root of cost accounting, as the U. S. Department of Agriculture has come to realize. But how did the men in this great department of our government come to such an awakening? Certainly not through holding in reverential awe the definitions and distinctions drawn by old though notable political economists. The new views that are beginning to prevail have mainly come from discussions just such as this one between our correspondent and ourselves, which, for the most part, have been discussions among engineers who were well acquainted with accounting and cost analysis, as well as with political economy. Appraisal and rate cases fought out before public service commissions during the past decade, in which engineers have almost invariably been the most important witnesses, have served to make it necessary to go most thoroughly into economic matters such as we are here discussing.

Hatfield, in his "Modern Accounting," says that to engineers and not to accountants belongs the entire credit for developing modern cost-keeping systems. Future political economists will have to give similar credit to engineers for evolving systems of scientific ratemaking or pricing, as well as for systematic studying and codifying the laws of scientific management.

Our correspondent's objections to our definitions of "price" and "value" are of no greater force than objections that can be raised against a given use of any term that is old and has been used in many senses.

Our correspondent makes a good point against the expression, "intrinsic value," but it is equally good against "intrinsic merit," or "intrinsic beauty," or "intrinsic" whatnot; for the fact is that nothing dependent on mental action for its "quality" is "intrinsic" or within itself alone. We might with propriety, therefore, banish the word "intrinsic" from the dictionary, if we are to insist on its original, literal meaning as the only one applicable.

Our correspondent warns us to be very sure of a statement, and overwhelming in the proof of it, if it is at variance with the tenets of great intellects of the past, whether in logic or economics. One may be very sure of his position, but one can seldom be "overwhelming" in the proof of it until he has been given time to present his proof and argument. A single article often gives inadequate opportunity to defend a position or to elucidate a principle sufficiently. Hence the welcome that a fair writer invariably extends to an honest critic.

As for the advice that an engineer should stick to engineering—"every shoemaker to his last"—our reply is that engineering is the application of science. If the science of logic and the science of economics, broadest of all sciences, are not the mold upon which the engineer shapes his "shoes," they are the legs of the bench upon which he sits.—Editor.]

INFORMATION WANTED ON ALLOWABLE LEAKAGE FOR CONCRETE RESERVOIR.

To the Editor: We are interested in securing reliable data in relation to the amount of allowable leakage for a concrete reservoir in which the concrete mix is 1:3:5 and the slab 6 in. thick. The concrete slab is reinforced with No. 27 triangular mesh. We might state that this slab is simply a lining in a clay puddled and rolled excavation. The banks slope at 1½ to 1 and the reservoir contains the following area: The reservoir is 14 ft. deep, 93 ft. square at the top and 52 ft. square at the bottom.

What coefficient for evaporation would be allowable in this case for ordinary concrete porosity, and what would be the coefficient for evaporation of an area of this size during the months of October, November and December?

USE OF STREAM FLOW RECORDS OF U. S. GEOLOGICAL SURVEY.

To the Editor—Referring to your reprint in your June 28, 1916, issue of Mr. Herschel's article before the Boston Society of Civil Engineers, his suggestion seemed to be in the main good, and if the records of the Hydrographical Survey were always dependable the 20 years' daily flow would be extremely valuable as a basis on which to prognosticate the flow, but if upon analysis and comparison with the rainfall these records are shown to give in some cases more than 100 per cent of the rainfall it is very important to consider the latter and find the cause of the discrepancy.

Many of the public documentary records of rainfall are undoubtedly of great value, but every engineer of experience in this line knows that it is not safe to take them always at their face value.

In a river it is customary to establish an elevation gage, and by means of observations with a current meter determine a rating curve of flow, wherein the abscissas represent the gage height and the ordinates the flow in second feet. This rating table, which may be based on anywhere from half a dozen to twenty or more flow determinations, is used thereafter to tabulate and diagram the flows.

It is a well-known fact that in a northern climate, where a river is subject to ice conditions for several months of the year, the flow for given gage heights may be much less than when the river is free from ice, but it is very seldom that a flow determination is made when the river is gorged with ice. Under these conditions, therefore, it is possible for a tabulation of flow to be very materially overstated. There are other reasons, which have frequently been pointed out by the writer, why such flows are sometimes liable to serious error. Although the courts always prefer actual gagings to methods of computation based on the rainfall, the engineer, who cannot afford to be deceived, must apply such methods as a check upon the public shed records, and when he finds a material discrepancy these proper methods of computation should be taken in preference to the others. However, there is no method of computation of a stream flow that is safe unless it is based on a large number of actual determinations of the flow coincident with the rainfall.

J. W. Ledoux,
Chief Engineer, American Pipe & Construction Co.
Philadelphia, Pa.

GRAVITATION.

To the Editor: I was very much interested in noting, in your issue of Jan. 31, in the article on "Some Principles of Logic for Engineers," the following statement: "The mysterious energy that we call gravitation is probably a bombardment of the free corpuscles, called ether, upon bound corpuscles, called matter."

In 1907 I wrote a paper on the subject, "Cohesion, Adhesion and Gravitation Identical." I sent it to the different scientific periodicals, but none of them would publish it. The "Engineering Digest" finally published it. My theory is that ether is in fact a substance moving at the speed of light and vibrations in the same make what we call light. This substance impinging on the molecules of matter causes the phenomenon called gravitation. The commonly accepted theory of light and the idea of "attraction" between bodies separated from one another are illogical in the extreme. But lack of logic does not seem to bother scientists.

Established theories and dogmas and standards are very jealously guarded by the "highbrows" of any profession, and woe to the iconoclast who would attempt to overthrow one of them! Ten years or more of adherence to a proven error does not bother these dictators of a profession nearly so much as the acknowledgment of that error.

Edward Godfrey.
Pittsburgh, Pa.

Cost of Operation and Comparative Cost of Chemicals for Columbus, O., Purification Works.—The total expense for operating and maintenance of the water softening and purification works of the city of Columbus, O., for 1916 was $199,299, of which $24,902 was for labor and supervision, $168,346 for chemicals and $6,051 for general supplies. The cost of purification per 1,000,000 gal. delivered to consumers was $27.75. The quantities and costs of chemicals used at the works during the past 8 years have been as follows:

	Lime.		Soda ash.		Alum.		Bleach.	
Year	Tons	Cost per ton.	Tons	Cost per ton.	Tons.	Cost per ton.	Tons.	Cost per ton
1909.....	2,467	$5.75	1,402	$17.50	624	$19.00	...	$....
1910.....	3,081	5.80	2,164	17.50	423	18.00	...	......
1911.....	3,860	5.42	1,776	17.50	590	17.50	...	......
1912.....	3,296	5.27	1,583	15.20	895	17.15	22	27.80
1913.....	3,629	5.17	[illegible]	12.88	711	17.10	17	27.80
1914.....	[illegible]	5.27	3,540	13.20	880	16.75	14	29.20
1915.....	3,970	5.17	2,383	15.14	69 805	*16.60 †7.27	22	34.80
1916.....	4,550	5.17	1,975	62.00	823	‡20.08	19	85.00

* Lump alum. † Homemade alum. ‡ Cost of materials.

Cost of New Water Mains at Detroit, Mich.—During the fiscal year ending June 30, 1916, the city of Detroit laid 259,671 lin. ft. or 49.18 miles of water mains. The unit cost, according to the 64th annual report of the Board of Water Commissioners, was as follows:

Size.	Number of feet.	Material, etc., per ft.	Labor, per ft.	Overhead expense, per ft.	Total, per ft.
4-inch..........	804	$ 0.56	$0.37	$0.05	$ 0.98
6-inch..........	118,523	.64	.45	.05	1.14
8-inch..........	81,010	.70	.45	.05	1.20
10-inch..........	2,055	1.28	1.02	.11	2.41
12-inch..........	3,908	1.58	.96	.11	2.65
16-inch..........	208	2.64	1.13	.13	3.90
24-inch..........	5,095	3.74	1.98	.25	5.97
48-inch..........	29,581	11.74	7.21	.84	19.79

EXTRACTS FROM LETTERS SHOWING WHAT THE SUBSCRIBERS THINK OF THE ROTATED SPECIAL MONTHLY ISSUE FEATURE OF E. & C.

I read E. & C. in order to keep informed on general engineering progress more than for reference to any special subject, and for this purpose I find your present arrangement much the best.

L. C. Britton,
General Manager, Alabama Central R. R.
Jasper, Ala.

I think your idea in separating your publications into the various branches of engineering is a most splendid one.

H. F. Cox,
Chief Engineer, Scranton Gas & Water Co.
Scranton, Pa.

I want to congratulate you on the changes you have made in the paper since I took it last, four years ago. Then I had to cut out articles on certain subjects that I wanted to save, but now the way the paper is published I can have the whole year bound.

Avalon, Pa. Charles D. Corp.

I think the plan you have adopted as to the issues is certainly good. Anyway, I like it.

Nixon, Nev. Chas. R. Jay.

The arrangement of your publication is a convenience and quite an improvement over unclassified articles.

Canton, O. J. F. Miller.

Waterworks men will be interested in the new policy of your journal, bringing all the articles on hydraulic subjects together.

Scotland G. Highland,
Superintendent Waterworks and Sewerage Board.
Clarksburg, W. Va.

I believe your specialization method of handling engineering subjects makes your paper worth twice as much as those which endeavor to include a large variety of engineering subjects in a single issue. I have been especially interested in the various editorials which have appeared from time to time, showing why the engineer should become more closely identified with matters of public concern.

W. G. Waldo.
Nashville, Tenn.

I find the present method far superior to the old plan. I hope you will consider the advisability of separate indices, which would enable the magazines to be bound according to matter wanted.

M. L. Jones,
Benton Harbor, Mich. City Engineer.

After having plowed through many current technical periodicals containing "multa sed non multum," it is a relief to be reminded of the old "Dirt Mover," and particularly with an excellent selection of good stuff. To my mind, your departure into "rotated specialization" is a step in the right direction, and I know several engineers and contractors who join me in those sentiments.

E. Lee Heidenrich, Consulting Engineer.
Kansas City, Mo.

Your new scheme in publishing your paper is splendid. I wish you all success.

John R. Zenisek.
Jackson, Mich.

I have always removed the articles of import and filed them under their different heads heretofore, and now I am entirely relieved of that trouble, for they come now under their proper heads in each weekly. I am more than pleased with Engineering and Contracting.

Three Forks, Mont. C. J. Donaldson.

LEAKAGE FROM NEWLY CONSTRUCTED PIPE LINES.

Opinions differ somewhat regarding the allowable leakage from newly constructed water pipe lines. In an endeavor to obtain information on this point letters were sent to a number of consulting engineers asking their experience and practice in the matter. Several replies are given below.

In an article in the Feb. 14 Waterworks and Hydraulic issue of Engineering and Contracting, Mr. Alexander Potter, Consulting Engineer, New York, gave the results of tests made at Corpus Christi, Tex., on 14.1 miles of cast iron force main. It should be noted here that this pipe was 20 in. in diameter instead of 18 in. as given in the table summarizing the results. Mr. Potter also included in his article a resume of the degree of the watertightness called for on several other works.

Tests of distribution mains before they were put in service were made last year by the Board of Water Commissioners of Hartford, Conn., of which C. M. Saville is Chief Engineer. The following data on these tests are taken from the recently issued 62d Annual Report of the Commissioners. The test pressure used was about 40 lb. in excess of that which ordinarily would come on the mains and was given to try out the joints should they be subject to sudden shocks from water hammer due to sudden opening or closing of gates. Tests on new mains in 18 streets are summarized in Table I. These cover 16,892 lin. ft. of pipe on which there were 4,479 lin. ft. of leaded joint. The results showed a leakage under pressure of 2,867 gal. in 24 hours, or about 0.64 gal, per joint in 24 hours. As a result of this testing a criterion has been established for acceptance of 1 gal. per 24 hours per lineal foot of joint on a pressure of 100 lb. per square inch. Any leakage under test conditions in excess of this standard is to be cause for thorough investigation before placing the new main in service. The cost of the testing averaged less than 1 ct. per lineal foot of pipe tested. The Water Commissioners will continue the plan of testing all mains before they are put in service.

TABLE I.—TESTS OF DISTRIBUTION MAINS BY THE ENGINEERING DEPARTMENT OF HARTFORD, CONN.

Location.	Date.	Size of main, inches.	Length, feet.	Joints on main pipe.	Lin. ft. of joint.	Pressure, lbs. per sq. in. Test.	Normal.	Leakage per 24 hours, gallons. Total.	Lin. ft. of joint.
Arnoldale Road	Sept. 14, 1915	20	2,325	194	1,017	93	40-50	130	0.128
New Britain Ave	Sept. 14	12	1,197	102	320	106	55-60	98	0.206
Asylum St.	Sept. 30	12	1,327	115	399b	119	65-75	432	1.080k
Seymour St.	Sept. 30	8	1,159	101	224c	109	60-65	194	0.867
Asylum St.	Oct. 16	12	1,070	99	341d	125	45-65	582*	1.700m
New Britain Ave	Oct. 29	10	620	54	148a	126	70-75	140	0.947
Allen Place	Nov. 5	8	1,076	93	206h	120	65	376†	1.820
Allen Place	Nov. 11	8	550	50	113g	120	50-65	75	0.670
New Britain Ave	Nov. 18	12	1,054	91	309f	125	50-55	97	0.313
Jefferson St.	Nov. 27	8	562	49	109i	105	55-60	162	1.485
Bartholomew Ave.	Dec. 4	8	692	66	162n	100	75	86.2	0.53
Westland Ave.	Dec. 27	8	610	53	115v	106	37	0	0
Warner St.	Jan. 14, 1916	8	567	51	115p	100	65-75	301‡	2.61‡
Maplewood Ave.	Jan. 27	8	556	49	109t	100	40-45	18	0.16
Warner St Ext.	Feb. 5	8	371	33	74r	100	75	0	0
Holcomb St.	Feb. 7	8	1,171	105	295s	121	20-45	10.8	0.0366
		12	204	18					
Park St.	Feb. 7	8	852	57	159u	101	40-70	21.6	0.136
Hamilton St.	Feb. 28	12	929	81	264w	103	75-85	143.5	0.544
Totals		..	16,892=3.2 mi.		4,479	...	.....	2,867.1	0.640

*Ordinary pressure here is 65 lb., leakage at this pressure, 27 gal. per 24 hours. †Large amount probably due to corporation cocks not entirely closed. ‡Large amount due to corporation cross-threaded in main. (a) Includes 4 6-in. joints. (b) Includes 10 8-in. and 11 6-in. joints. (c) Includes 8 6-in. joints. (d) Includes 4 8-in. and 14 6-in. joints. (f) Includes 15 6-in. joints. (g) Includes 4 6-in. and 2 4-in. joints. (h) Includes 6 6-in. and 2 4-in. joints. (i) Includes 4 6-in. joints. (k) Includes some leakage at an 8-in. connecting gate. (m) Includes some leakage from an 8-in. gate. (n) Includes 14 6-in. and 2 4-in. joints. (p) Includes 4 6-in. and 2 4-in. joints. (r) Includes 3 6-in. joints. (s) Includes 8 6-in. and 6 4-in. joints. (t) Includes 3 6-in. and 2 4-in. joints. (u) Includes 25 6-in. joints. (v) Includes 1 6-in. and 2 4-in. joints. (w) Includes 6 6-in. joints.

Table II contains data on leakage in street mains collected by John Alvord and Chas. B. Burdick, Consulting Engineers, Chicago. In this table in considering leakage the standard of gallons per day per foot of diameter is used.

Opinions of several consulting hydraulic engineers on the allowable leakage from newly laid water mains follow:

Robert E. Horton, Consulting Engineer, Albany, N. Y.: In the case of cast iron pipe, it is my belief that if properly leaded and caulked, there should be practically no leakage when the line is new if it is laid in a trench. By practically no leakage I would mean that possibly one joint in 10 or 20 might show a very slight sweating. If the pipe is laid on the ground surface, or allowed to become repeatedly heated and cooled, it is impracticable to prevent some leakage. In most cases a leakage loss of 100 to 200 gal. per 24 hours per inch of diameter and per mile of pipe is absolutely inconsequential. It will not show up at the ground surface if it is uniformly distributed throughout the joints, and does not in most cases occasion enough water loss to be serious. I think that with properly caulked pipes, leakage should be capable of being limited to these amounts. However, leakage is

TABLE II.—LEAKAGE IN STREET MAINS.

Place.	Date.	Observer.	Miles.	Size. Ins.	Equivalent Miles 12-in Main	Age.	Pressure.	Leakage Total in gals per day.	Gals. per mile per day.	Gals. per mile per ft. of dia.	Remarks.
Glencoe, Ill.	1896	Annual report	15½	4-10	..	..	..	......	.....	800	Meter readings for 3 months checked with midnight readings.
		C. B. Brush	11	24	22	1	107	70,000	6,400	3,200	Test.
Milton, Mass.	1901	Freeman	32	...	..	10	85	..	3,372	.....	Night rate—2 to 5 a. m.
	1901	Loweth	..	....	..	..	..	..	.....	720-960	Conclusion of number of tests on small works—A. S. C. E. 1897, pp. 30.
Oskaloosa	1901	Burdick	6	10-12	..	*½-†½	60	.	.....	6,350	Test.
Oskaloosa	1901	Burdick	17	4-12	..	..	..	.	.....	7,800	Includes services.
		H. T. Dunham	..	4-16	..	..	50	.	1,440	.. ..	Actual test, location not given.
		John A. Cole	8	....	.	..	..	. .	4,750	.....	Actual test, location not given.
Yonkers, N. Y.	....	Ed. S. Cole	..	...	..	..	..	.. .	2,000	...	Estimated.
Detroit	1897	G. S. Williams	.	4-10	.	..	..		1,000	.....	Test—Am. Soc. C. E. 1897, pp. 35.
Cleveland	1911	Annual report	500	....	.	..	..	.	4,300	..	
								.	500 to 1,200	....	Torneaure & Russell for well constructed pipe system.
									500 to 3,000	. ...	Folwell for well constructed pipe system.
Gary, Ind.	1909	Alvord & Burdick	20	6-30	17	New	150	.	.....	2,600	Kalamein pipe—Data, from test.
Saugatuck	1904	Alvord & Burdick	1.7	4-8	.78	New	..	1,500	.....	5,500	Final test Dec. 8, 1904, includes river crossing with flexible joints.
Kincaid, Ill.	1914	Alvord & Burdick	5.1	4-10	2.1	New	90-110	2,370	470	960	Tank measurements after stopping two leaks.

*New. †20 years.

likely to be greater than it appears, because it is most likely to occur underneath the pipe where it is hardest to get at the caulking and to insure a perfectly caulked joint.

Charles C. Hopkins, Consulting Engineer, Rochester, N. Y.: In 1886 I was engaged to take charge of the repairs to a newly constructed system of water works, built without engineering inspection, but under the direct supervision of a contractor who I have every reason to believe was in all respects honest and who wished and intended to do good work. The piping system consisted of cast iron pipes from 8 to 4 in. in diameter, laid with the usual lead joints. The static head on the system was generally about 150 ft. The system leaked an average of 5,000 gal. per mile per 24 hours at the time I took charge of the work. After about two months spent in uncovering and recaulking the major part of the system, the leakage was reduced 80 per cent, or to 1,000 gal. per mile per day. I considered this satisfactory and so reported, but the officials of the municipality claimed it should be bottle tight. The system was then again generally uncovered, recaulked and a test showed a leakage of only about 200 gal. per mile per day, and it was accepted by the municipality. At this time little had been done in the way of testing piping systems to determine whether or not they leaked or the extent of leakage. From that time on it has been my practice to require in my contract specifications a leakage test upon the completion of a piping system, and to allow a certain leakage which shall not render the system unacceptable. The old prevailing idea that material leakage would show at the surface of the ground, I have found erroneous in many instances. It is customary for me to allow 400 to 500 gal. leakage per mile per day for small pipes of 10 to 4 in. in diameter where the static head is from 100 to 200 ft., increasing the allowance with larger pipes or greater static head. It requires good workmanship to come under the above requirement, although I have had it bettered more than 50 per cent. To say that a new system can be made bottle tight is untrue. The testing of the system by sections in the trenches before covering is no guarantee that it will be tight after covering, although it is desirable to so test it where that can be done without undue expense, as it precludes the probability of serious leakage or other imperfections being covered and difficult to locate later on.

H. K. Barrows, Consulting Engineer, Boston, Mass.: My practice in this matter is to always test a pipe line in sections and before backfilling wherever that is practicable, and in this way insure substantially tight joints. Where it is not possible to test the pipe in sections before backfilling, my experience has been that it requires extraordinary care in construction in order not to overlook defective joints. I have never adopted any fixed rule in regard to the allowable amount of leakage, but prefer to settle each case by itself. If the work is carefully done, however, the amount of leakage should be insignificant. I have found in some cases where leaks developed eventually that a very satisfactory method of treatment was to use lead-wool in recaulking the joints.

Weston & Sampson, Consulting Engineers, Boston, Mass.: In our opinion the most effective method of preventing leakage is the careful inspection of the pipe in the open trench before backfilling, under a pressure at least 50 per cent in excess of the maximum static pressure expected in practice, followed by the recaulking of all leaky joints. Where this is practiced, leakage may be easily reduced to less than 100 gal. per day per mile per inch in diameter of pipe. When pipe is laid in the ordinary way without testing leakages, as high as 5,000 gal. per day per mile per inch of diameter of pipe have been known to occur, and leakages of 3,000 gal. per mile per inch may be expected.

Burns & McDonnell, Consulting Engineers, Kansas City, Mo.: The general rule that we have felt was satisfactory is to allow 100 gal. per inch mile in cast iron pipe distributing systems at 100 lb. pressure. For example, a distributing system having the equivalent of 10 miles of 8-in. pipe carrying 100 lb. pressure would give a permissible leakage of 8,000 gal. per day. This to be a maximum. We have had cases where the leakage was practically nothing, which leads us to believe that it is largely a matter of care and time spent in caulking of the joints and in eliminating other possible sources of leakage, such as through drip valves of fire hydrants and other accessories. In our formula we assumed the element of pressure. We could not vouch to say, however, that the permissible leakage will increase or decrease proportionately for pressures other than 100 lb. Some sources of leakage undoubtedly occur, and at certain definite pressure, below which the leakage would be zero, and above which it might be quite noticeable—as, for example, the opening of an unobserved crack in a pipe. Such a pipe might not open at all and permit any leakage under a moderate pressure, but might become considerable under a higher pressure.

ALKALI ACTION ON CEMENT DRAIN TILE AND CONCRETE.

Investigations have been under way for some months at U. S. Reclamation Projects to determine the durability of cement drain tile and concrete in alkali soils. The Bureau of Standards will publish shortly a bulletin covering the first three years' tests (1914, 1915 and 1916). In the March Reclamation Record, Mr. E. C. Bebb, Engineer, U. S. Reclamation Service, summarizes briefly the more important results obtained thus far and gives some of the conclusions reached. The matter following is taken from Mr. Bebb's article:

Drain Tile.

Although the grand averages of all the tile of each individual series are generally higher in 1916 than in 1915, and in some cases higher than 1914, many individual tile showed partial or complete failure at several of the projects. At none of the projects were the tile found collapsed when the drain was opened, but many tile were so cracked or swollen or otherwise weakened by the alkali that they were broken in removal. This was especially true where the drains were carrying considerable water.

Resistance of cement tile to alkali action is found to vary in a general way with the consistency of the mixture and the method of manufacture. The following grouping is therefore made for convenience of comparison:

(a) Plastic Mix—Machine Made.—Tile of this group, of the proportion 1 part cement to 4 parts sand, have been found to contain varying quantities of salts in all experimental drains where exposed to alkali waters and at five of the eight projects swelling, cracking, and partial disintegration has occurred. Tile made of 1 part cement to 3 parts sand, with a few exceptions, have given no indications in the crushing tests that they have been seriously affected although alkali salts have been found in the walls of many of the tile, and in one case swelling and cracking were observed.

(b) Plastic Mix—Handmade.—Tile of this group have been found generally to contain salts wherever exposed to alkali water. In some cases swelling and cracking were observed. These tile are made of 1:2 and 1:2.5 mixtures, but their resistance to alkali is apparently no greater than that of the leanest mixture of group (a). The inefficiency of hand tamping of a plastic or dry mixture is clearly shown by these tile.

(c) Quaking Mix—Handmade.—Of this group, the tile of 1:2.5 mixture were hand tamped, and those of 1:1.5 and 1:2 mixture were made on a jigging device. No salts have been found in any of these tile when tested, but one tile at Roswell and two at Montrose, all of the jig make, were attacked and disintegrated on the surface. With few exceptions these tile when tested have appeared dry, or wet in spots only, in the interior of the wall. The hand-tamped tile of this group are the only tile which have to date shown no disintegration nor alkali salts in the pores at any of the projects.

(d) **Fluid Mix—Handmade.**—In this group are included series 14 (1 part Portland cement to 3 parts sand) and series 15 (1 part sand-cement to 3 parts sand). The sand-cement tile have shown alkali in the pores and in numerous cases have shown a softening of the surface, which action was first noticed at Montrose in 1914, when the first year's tests was made. Series 14, mostly nearly comparable with the hand-tamped tile of group (c), has usually been found dry, or damp only in spots.

During 1916, absorption tests and crushing tests of both dry and saturated specimens were made on tile of each series which had been stored since the initiation of this investigation in the open air at Ames, Ia. It was found that the absorption resulting from 18 days' immersion in ordinary fresh water reduced the strength of the tile from 10 to 30 per cent. Comparison of the amount of absorption of the different series with the results obtained for these tile when exposed to severe alkali conditions shows conclusively that the tile having the lower absorption are the more durable.

The following conclusions may be drawn for the use of cement drain tile exposed to soils or water containing alkali salts in quantities of 0.1 per cent or more, similar in composition to those encountered in this investigation.

1. Porous tile due to the use of lean mixtures or relatively dry consistencies are subject to disintegration. Some dense tile are, under certain conditions, subject to surface disintegration.

2. Disintegration is manifested by physical disruption caused by the expansion resulting from the crystallization of salts in the pores and by softening resulting from chemical action of the solutions with the constituents of the cement.

3. While results obtained will not permit of a definite statement as to the relative effect of the various constituents of the salts, indications are that the greater the quantity of the sulphate and magnesium present and the greater the total concentration of salts, the greater will be the disintegrating effect.

4. Tile made by the process commonly used, which allows the removal of forms immediately after casting, are subject to disintegration where exposed to soils or waters containing 0.1 of 1 per cent of alkali salts similar in composition to those encountered in this investigation.

5. Hand-tamped tile of plastic consistency as made in this investigation are not equal in quality to machine-made tile of the same mixture and they do not resist alkali action as well, but hand-tamped tile of quaking consistency are least porous and most resistant to alkali of all tile tested.

6. Steam-cured tile show no greater resistance to alkali action than tile which are cured by systematic sprinkling with water.

7. Tile made of sand-cement have less resistance to alkali action than tile made of Portland cement of the same proportions.

8. Ordinary coal-tar coating, cement grout coating, or the introduction of ferrous sulphate into the cement mixture is not effective in preventing the absorption of alkali salts from the soil.

If cement drain tile are to be used in soils or waters containing alkali salts similar to those encountered in these investigations they should be made of good quality aggregates in proportions not leaner than 1 part cement to 3 parts aggregate. The consistency should preferably be quaking, which has proved the most resistant of all mixtures used. This is a wetter mixture than that generally used in commercial tile plants and will probably require the retention of the tile in the mold for several hours unless some means are found to hasten the hardening of the cement.

Concrete Blocks.

After one year's exposure none of the 1:1.5:3 proportion blocks molded at Denver with selected aggregates (series A) have shown signs of disintegration on any of the projects. The 1:2.5:5 proportion blocks have also been unaffected, with the exception of those installed on the Sun River and Grand Valley projects, where slight scaling and pitting was shown for a distance of 2 to 6 in. above the ground level.

Blocks of series B, made of local aggregates on each project and cured for one month before being placed in the alkali soil, were unaffected on the Shoshone, Yakima, and Truckee-Carson projects. On the Sun River, Rio Grande, and Uncompahgre projects the deterioration was confined to surface scaling and pitting above the ground line. At Grand Valley the blocks of the leaner mixture (1:2.5:5) were disintegrated to a depth of ½ in. just above the ground line, and at Belle Fourche all the blocks were partially disintegrated above the ground line.

Blocks of series C, made of local aggregates and molded in place in the alkali soil, were unaffected on the Grand Valley, Yakima, and Truckee-Carson projects. Surface scaling and pitting of the leaner mixtures only was noticeable at the Shoshone, Sun River, and Uncompahgre projects. At Rio Grande both mixtures showed scaling and pitting. At Belle Fourche the blocks of 1:1.5:3 mixture were only slightly scaled and pitted, but the 1:2.5:5 mixture were disintegrated for a depth of 2 in. at the ground line and the concrete was soft at this point. It is noticeable that the blocks of series C are in better condition than those of series B on all projects except the Shoshone.

Blocks made of sand-cement concrete molded at Denver were installed on the Grand Valley project. The two 1:1.5:3 proportion blocks were scaled and pitted for a distance of 6 in. above the ground surface, while one block of proportion 1:2.5:5, was disintegrated to a depth of 1 in. The second 1:2.5:5 proportion sand-cement block, made of such a dry consistency that rough surfaces and corners resulted in molding, was unaffected by the alkali.

Natural cement blocks of the proportion 1:1.5:3 were molded on the Grand Valley project in a manner similar to the series B blocks. These blocks were entirely disintegrated three months after being installed.

No definite conclusions can yet be drawn as to the ultimate resistance of concrete when exposed to the most severe action of alkali on the projects. However, the complete failures found at the Belle Fourche project where the local materials used were of rather inferior quality, together with the action which has commenced on the surface of many of the blocks on other projects, indicate that materials of good quality and proper workmanship are of greatest importance.

The surface action noted on blocks at several of the projects was not confined to those made of local materials, but was also apparent on some of the blocks made of selected aggregates (series A molded at Denver). Whether or not this surface action on the best quality concrete blocks is progressive will be apparent after a longer period of exposure. Concrete which is to be placed in alkali soils should be made of selected and tested materials so proportioned as to produce a dense concrete. As small an amount of mixing water should be used as will allow the mass to be properly placed. Unless these precautions are taken, the resistance of the concrete to alkali action will be reduced.

Lining Waterworks Tunnel with Concrete.—A pneumatic mixer and conveyor, one of four in use in the Wilson Ave. tunnel of the Chicago water supply system, made a new record during January. It mixed and placed concrete in three 30-ft. lengths of forms daily and on four days, two of which were successive days, four forms were completed. The men have been working two 8-hr. shifts. The tunnel is 12 ft. in diameter and the concrete lining varies from 1 ft. to 18 in. in thickness and will average 2 yd. of concrete per lineal foot. The pneumatic mixer and conveyor was furnished by the Concrete Mixing & placing Co., Chicago.

WATER STERILIZATION BY MEANS OF CHLORAMINE.

Contributed by Joseph Race, City Bacteriologist and Chemist, Ottawa, Ont.

About a year ago the author made a number of experiments on the relative efficiency of various hypochlorites, and after determining the values for the sodium, potassium, and calcium salts, the ammonium salt was prepared by double decomposition of the calcium salt and ammonium oxalate. The solution so obtained gave very abnormal values averaging about 300 per cent of those shown by other hypochlorites containing equal quantities of available chlorine and it appeared probable that the ammonium hypochlorite was unstable and decomposed spontaneously into water and a substituted ammonia known as chloramine. Thus—

$$NH_4OCl = NH_2Cl + H_2O$$

The high germicidal value of substituted ammonias had previously been noted by S. Rideal, who showed that chloramine had a carbolic acid coefficient three times as great as that of chlorine, but no attempt appears to have been made to utilize this discovery for water or sewage sterilization.

The author followed up this line of investigation and prepared chloramine by the addition of aqua ammonia to solutions of bleach. Laboratory work showed that the highest efficiency was obtained when the available chlorine and ammonia were in the exact proportions required by the formula NH_2Cl. This requires two parts by weight of available chlorine to one part by weight of anhydrous ammonia.

The experiments were next carried to the works scale and a small plant pumping 200,000 Imp. gal. per day was found to be available for this purpose. At first the required amount of strong ammonia (0.880) was added directly to the 0.5 per cent solution of bleach in the storage barrels which were of four hours' capacity. This method of application gave results inferior to hypochlorite alone and it was found that the mixture of hypochlorite and ammonia progressively deteriorated in strength. Laboratory experiments confirmed this and showed that even when the solution contains less than half of 1 per cent of available chlorine the ammonium hypochlorite gradually decomposes, not into chloramine and water, but into gaseous nitrogen and bodies containing inert chlorine. The mixing arrangements on the plant were accordingly altered and the bleach solution and ammonia were prepared in separate vessels and admixture made in the pipe discharging the bleach solution into the intake pipe. In this manner the solutions were only mixed for a very short period before being diluted with the water to be treated and no decomposition was found to occur. This method gave satisfactory results at once and the dosage was gradually reduced until the bacteriological purity of the water was adversely affected. The dosage was continued at the minimum figure for several weeks to secure information as to the reliability of the process and to eliminate the possibility of adventitious results. The results for this period are given in the tables, the straight hypochlorite figures given as a basis of comparison being obtained with the main plant treating 20,000,000 Imp. gal. per day.

The cost data are calculated on recent spot prices for bleach and aqua ammonia (26°B), but if the prevailing Canadian prices are substituted the chloramine treatment shows an even greater economy.

During February, 1917, a further increase in the price of bleach gave an opportunity of trying the process on the main plant which has a daily capacity of 20,000,000 Imp. gal. The ammonia used in this case was commercial aqua ammonia (26°B) containing 29.4 per cent of anhydrous ammonia. This material was carefully examined for such noxious substances as cyanides and found to be eminently satisfactory. The method of application was the same as was found satisfactory on the experimental plant and the bleach dosage was gradually reduced as the ammonia was increased. The dosage was checked and controlled by the usual starch-iodide reaction at the plant and in the laboratories of the Health Department, and also by frequent bacteriological examinations.

At the time of writing the amount of bleach added has been reduced over 60 per cent and the cost of material is about $16 per day less than the average for the past year.

A further example of the efficiency of this process was found during a series of experiments on the disinfection of the water of a swimming pool at the Ottawa Y. M. C. A. This pool was being extensively used by the various military units stationed in Ottawa, in addition to the members of the association, and it was found that frequent changes of water were necessary in order to avoid complaints. The cost of raising the temperature of the water 20 to 25° F. quickly became a serious financial consideration and the author was requested to suggest some method of disinfection which would enable the water to be retained at least 7 days. Hypochlorite was first used, but even with doses as high as 3 parts per million of available chlorine, aftergrowths rapidly occurred and total bacterial counts of 50,000 to 100,000 were repeatedly found: the B. coli index was usually 2 to 5 per c.cm. Hypochlorite treatment at this dosage was a total failure and it was deemed undesirable to use larger amounts on account of the tendency to cause irritation of mucus membranes.

Chloramine treatment was next used and after the attendant had become thoroughly conversant with the proper method of application, very satisfactory results were obtained. The treatment finally adopted was 1 part per million of chlorine with 0.5 part per million of ammonia and this, when conscientiously carried out, produced a water containing less than 100 bacteria per c.cm., and free from B. coli in 10 c.cms. The elimination of the aftergrowths by the chloramine treatment is due to the non-absorption of the germicide so that all of the added substances are available for the destruction of bacteria.

With waters that absorb but little chlorine, the relative efficiency of chloramine to hypochlorite would probably be lower than for waters containing appreciable quantities of organic matter, and for the same reason the process should be admirably suitable for the treatment of sewage and sewage effluents.

The increased efficiency obtained by the addition of ammonia to hypochlorite naturally suggests a similar mixture with liquid or pure chlorine, but the efforts of the author in this direction have not yet yielded results

TABLE I.—COMPARISON OF HYPOCHLORITE AND CHLORAMINE TREATMENT—BACTERIOLOGICAL RESULTS.

	Raw Water			Treated with Hypochlorite Alone				Treated with Hypochlorite and Ammonia				
	Bacteria per c.cm.			Bacteria per c. cm.				Bacteria per c.cm.				
1916.	Agar 1 day at 37° C.	Agar 3 days at 20° C.	B. Coli Index per 100 c.cms.	Agar 1 day at 37° C.	Agar 3 days at 20° C.	B. Coli Index per 100 c.cms.	Available Chlorine p.p.m.	Agar 1 day at 37° C.	Agar 3 days at 20° C.	B. Coli Index per 100 c.cms.	Available Chlorine p.p.m.	Ammonia p.p.m.
Apr. 1-19	3,099	14,408	195.5	32	56	0.50	1.10	4	12	0.14	0.22	0.11
Mar. 15-31	44	238	35.7	4	12	<0.14	0.90	33	246	0.74	0.25	0.13

TABLE II.—COMPARISON OF HYPOCHLORIATE AND CHLORAMINE TREATMENT—PERCENTAGE REDUCTION.

	Hypochlorite Alone				Hypochlorite and Ammonia			
	Bacteria per c.cm.				Bacteria per c.cm.			
1916.	Agar 1 day at 37° C.	Agar 3 days at 20° C.	B. Coli Index per 100 c.cms.	Available Chlorine p.p.m.	Agar 1 day at 37° C.	Agar 3 days at 20° C.	B. Coli Index per 100 c.cms.	Available Chlorine p.p.m.
April 1-19	98.9	99.6	99.7	1.10	99.9	95.0	[illegible]	0.22
March 15-31	90.5	97.8	99.9+	0.90	[illegible]	98.9	99.6	[illegible]

TABLE III.—COST PER MILLION IMPERIAL GALLONS.

1916.	Hypochlorite Alone.	Hypochlorite and Ammonia.
March 15-31	$1.12	$0.46
April 1-19	1.26	0.54

Calculated on bleach at $3.80 per 100 lbs. and Aqua ammonia (26° B.) at 5¾ cents per lb.

worthy of publication. The difficulty apparently lies in the non-production of hypochlorous acid by pure chlorine and water and the consequent inability to form chloramine. New conditions, however, may be found that would direct the reaction along these lines.

It has been suggested that the influence of the ammonia is to increase the oxidizing activity of the chlorine, but this view is not supported by the evidence available. If the oxodizing effect were accelerated, the mixture would be even more readily absorbed by waters containing readily oxidizable organic matter than hypochlorite alone. Experiments demonstrate the reverse, for it was found that on adding 10 p.p.m. of available chlorine as hypochlorite to the Ottawa River water, about 35 per cent was absorbed in 5 minutes at 60°F. and 60 per cent within 1 hour; if an equivalent of ammonia were first added to the solution, only 1.4 per cent of the available chlorine was absorbed in 1 hour and 3.2 per cent in 20 hours.

Again, the oxidizing effect of hypochlorite can be measured by its bleaching effect on dyestuffs and Rideal (Jour. Roy San. Inst. XXXI, No. 2, 1919, p. 40) has shown that the addition of an equivalent of ammonia to hypochlorite solutions reduces the bleaching efficiency to approximately 2 per cent of the original value; these results have been confirmed by the author and conclusively prove that the enhanced germicidal effect of chloramine is in no way connected with oxidation.

Further studies on substances containing the chloramine group (:NCl) by Dakin et al (Jour. Roy. Soc., 1916, B. 89, 232-251) would suggest that the usual conception of the germicidal effect of chlorine and hypochlorites being due to oxidation may be erroneous and that the action should be at least partially attributed to the chloramine derivatives produced by the action of chlorine on amino acids and protein.

THE USE OF BOATS FOR MAKING STREAM MEASUREMENTS.

In connection with the hydrometric surveys of the Department of the Interior of Canada many measurements in the Peace River District were made by means of boats. A description of the methods employed in this work is given by Mr. P. H. Daniels, District Hydrometric Engineer, in the report of Hyrometric Surveys for 1915 issued last month by the Canadian Department of the Interior. The following notes are taken from this report:

Ferry Boats.—Two types of ferry boats were used. First the ordinary scow ferry. This boat was not very well adapted to the work because of the difficulty of keeping it in a constant position and because it could not be used in swift water as the increased pressure on the cable, when the boat was turned squarely against the current, was too great. Also the current-meter must be suspended from one end of the ferry on account of the velocity immediately in front or at back of the boat being affected by the submerged portion, and as the boat always swings from side to side to a small extent, this will cause a small error in the recorded velocities.

The second type was the pontoon ferry and as a boat for stream measurement work this design could hardly be improved upon. This boat, as shown in Fig. 1, consists of a platform bridged across two sharp-nosed scows. The scows are about 10 ft. wide and are placed 12 ft. apart. The platform is so far forward that the stern end of it is quite close to the center of the ferry, and if the current meter is suspended at the point (A), any error in the recorded velocities caused by the swinging motion of the boat is eliminated. The velocity of the water under the center of the bridge is not disturbed by the submerged portion of the scows. This type of boat can be used in any stage of water, the pressure on the cable being much less when the boat is stationary than when it is in motion. The total length of the ferry is about 30 ft., and it is, therefore, possible to use a proper stay line.

Boat and Anchor.—This method was used with two types of boats, a motor boat and a canoe. The former was the most satisfactory for several reasons. It can be used in faster water and if properly equipped a stay line can be used. Owing to its greater weight a motor boat can be held stationary in a fairly hard wind while a canoe, even though anchored from both bow and stern, will shift slightly from side to side in a gentle wind and if the wind is strong across the river or upstream it is impossible to use a canoe with any degree of accuracy. The greatest disadvantages of a canoe are that a stay line cannot be used and that it does not allow the operator to move around freely. In this work it was used only when it was impossible to employ any other method. The meter was suspended about 4 ft. in front of the boat and on account of no stay line being used velocities were read at a depth of 4 ft. The boat was anchored at both bow and stern. This method was very slow, it being necessary to lift both anchors entirely out of water before any progress can be made with the boat and in a fairly swift current it took several minutes to get back to the line of measurement. It was quite difficult to judge the distance between soundings with any accuracy, especially if the interval of paddling was very long, and often it was necessary to make two or more attempts before the proper location was reached.

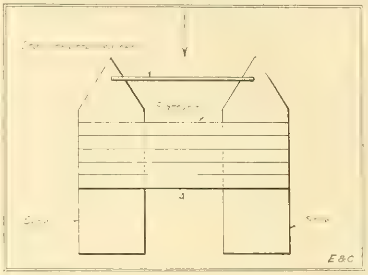

Fig. 1—Pontoon Ferry Boat.

With the motor boat the meter was suspended from the stern and about 4 ft. to one side of the boat. The boat was anchored from the bow only. By use of the engine it was possible to move quickly and without lifting the anchor out of the water and soundings could be made at fairly regular intervals with very little difficulty. The engine was running at all times, but with the clutch thrown out after the boat was anchored.

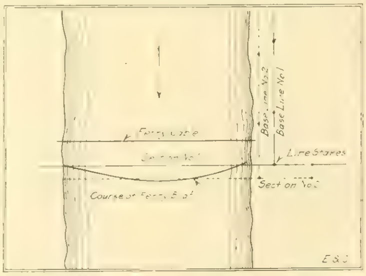

Fig. 2—Method of Measuring From Ferry Boat.

With any type of boat it is difficult to judge the distance between soundings, especially near the center of the stream. Attempts were made to overcome this by using floats anchored at regular intervals across the stream. This method worked very well in shallow and sluggish water, but in deep fairly swift water it took so long to arrange the float and anchor it in the proper location that it was decided it was faster and easier to take the soundings at closer intervals and make sure of the distances in that way.

In all classes of both measurements, except those made with a boat and cable, it was necessary to measure the distances of soundings by means of triangulation. In this case a sextant was used and angles were read from the boat. A much more satisfactory way would be to use a transit and measure the angles from the shore, but this would require an extra man.

Two stakes were placed on line with the measuring section so that the boat could be kept on line. From the stake nearest the river's edge an angle of 90° was turned and a base line carefully measured. Stakes were placed along the base line at such places as would make the angles read neither too large nor too small. For instance, on the Peace River at Fort Vermilion, where the river is about 1,800 ft. wide, a 1,500-ft. base line was used. Stakes were put in at 200, 500, 1,000 and 1,500 ft. from the line of measurement and the angles read from the first stakes for distances up to about 300 ft., then from the second stake, etc. Even distances were used to simplify the computations.

In the case of a ferry boat measurement, such as on the Peace River at Peace River Crossing, a slightly different method was necessary. At this point the river is about 1,500 ft. wide in high water and, owing to this fact and on account of the swiftness of the current, the ferry boat does not pursue a straight course across the river, but goes down stream for a considerable distance as it approaches the middle of the river and the slack is pulled out of the cable. Even by moving from end to end of the boat it was impossible to keep on the measuring line, therefore it was necessary to lay out two separate lines, one about 50 ft. from the other. The full line, Fig. 2, was used for measuring angles between 0 and 500 and between 1,000 and 1,500. For the intervening distance the dotted line was used.

Soundings.—A little difficulty was experienced in getting accurate soundings. This was caused by trying to use the ordinary methods. At Peace River Crossing the party was able to use a stay line and a weight of about 225 lb., but under the worst conditions encountered, a depth of 28 ft. and a velocity of over 10 ft. per second it was impossible to know whether the weight was on the bottom of the river or was being supported by the stay line. It is not believed accurate results can be obtained by the use of a stay line under such conditions. It was found that by using a 15-lb. weight on a very light line, about 1/8 in. in diameter, and throwing it upstream as far as possible, the depth could be accurately measured just as the weight was passing the boat in the current. In the case mentioned it was also impossible to tell when the meter was at the proper depth for readings, and readings were taken at a depth of 3 ft., and a constant, which had been determined from several vertical velocity measurements made in the same stream but in slower water, applied.

Operating Conditions of Mechanical Filter, Columbus, O., for 1916.—The purification works of Columbus, O., were placed in operation in September, 1908. They include a coagulating basin of 15,000,000 gal. capacity, a filtered water basin of 10,000,000 gal. capacity and 10 filter units of a net area of surface of 10,800 sq. ft. The filtering material consists of 10 in. of gravel and 36 in. of sand. The operating conditions of the filters for 1916, according to the report of Charles P. Hoover, Chemist in charge, was as follows:

	Average length of runs, hours, during 24-hour period.	Average length of filtered runs between washings.	Average loss of head		Washing Average time in minutes.		Per cent wash water.	Period of plain subsidence, hours.	Period of coagulation, hours.
			Initial.	Final.	Air.	Water.			
January	18.7	27.2	7.0	0	0	3	1.1	0	20
February	17.2	26.1	6.9	0	0	3	1.0	0	19
March	17.2	30.5	6.0	0	0	3	1.0	0	20
April	19.1	31.5	6.0	0	0	3	1	0	21
May	19.8	39.1	5.0	0	6	3	.8	0	20
June	19.6	44.1	5.[illegible]	0	0	5	1.0	0	16
July	15.3	26.0	5.1	0	0	[illegible]	.9	0	15
August	18.3	38.7	4.4	0	0	5	.9	0	16
September	17.5	41.4	4.3	0	0	5	1.0	0	17
October	19.0	55.9	3.1	0	0	[illegible]	.6	[illegible]	18
November	18.1	49.0	3.1	0	0	5	.8	0	19
December	19.1	40.1	4.6	0	0	3	.8	0	17
Average	18.2	37.7	5.1	0	0	1	.9	0	19

DESIGN NOTES ON OVERHEAD SYSTEMS OF IRRIGATION.

The possibilities of the overhead (spray) system of irrigation were pointed out in the Dec. 13, 1916, issue of Engineering and Contracting. In the Jan. 10, 1917, issue the method of supporting and operating the overhead piping was described and in the Feb. 14 issue a description was given of one of the largest overhead irrigation installations in this country. The U. S. Department of Agriculture has issued recently a bulletin on Spray Irrigation. Extracts from the bulletin follow:

Economic Conditions Justifying Spray Irrigation.—The cost of spray-irrigation systems depends upon the type installed as well as upon conditions peculiar to each form. A portable outfit may cost as little as $50 per acre for the field equipment, while a stationary distribution system may cost as much as $150 per acre. To these figures must be added the cost of a main pipe line leading from the water supply to the fields and usually the cost of developing a water supply and installing a pumping plant. These additional items may bring the total outlay per acre up to two or three times the cost of the distribution system, especially on small acreage. Assuming a cost of $250 per acre on a stationary plant for a small acreage, the farmer should be able to increase his annual returns from each acre to cover approximately the following charges:

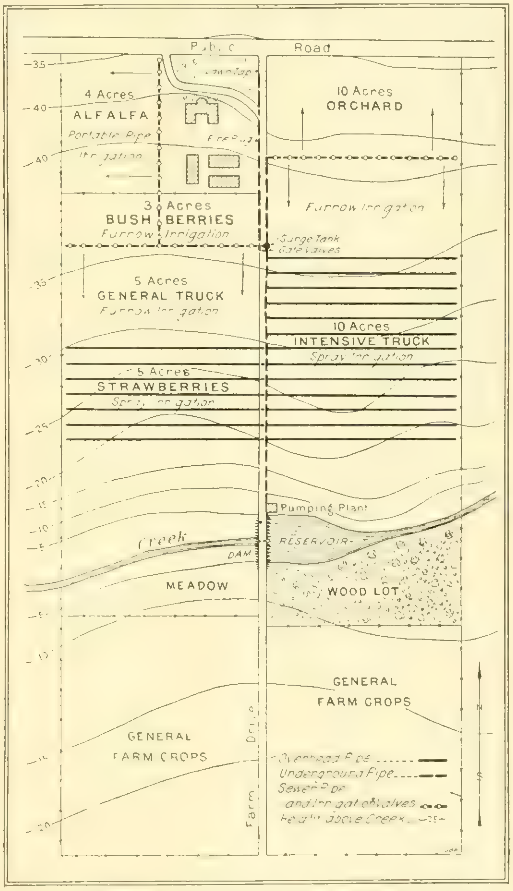

Fig. 1—Typical 80-Acre Farm in Humid Regions, Showing Development of Water Supply by Reservoir and a Combination of Spray and Surface Methods of Irrigation Operated from One Pumping Plant.

6 per cent interest on $250	$15.00
5 per cent depreciation on equipment	12.50
2 per cent maintenance and repairs	5.00

Cost of fuel and oil at 4 cts. per 1,000 gal. of water pumped for 6 acre-inches	*6.50
Labor in irrigating, 1 man 6 days at $2	12.00
Total overhead and operating expenses	$51.00

It will be noted that $51 per acre per year is necessary in returns to cover overhead and operating expense incidental to the spray system. To realize a fair profit from the irrigation plant, the crops must increase in value something more than $51 per acre. In the case of berry, tobacco, and orchard crops the increase must be derived from one main crop and a possible intercrop. On the other hand, the irrigator of truck who follows intensive culture has a chance of dividing the annual increase among three to six crops. The high cost of spray irrigation eliminates its use on many crops which respond readily to irrigation. It is possible, however, to use cheaper methods of distribution on many of these crops which are grown on land having an even surface. A combination of spray irrigation and surface methods on the same farm often can be placed under one pumping plant, as illustrated in Fig. 1, thereby utilizing to the fullest extent the water supply, pumping equipment, and main pipe lines. The typical farm illustrated in Fig. 1 indicates the use of spray irrigation on the more uneven parts where the topography is not adapted to cheaper methods, but where the soil and southern slope are desirable for the growing of early and intensive truck and berry crops that will justify spray irrigation. The main feed pipe is extended to the upper and more even parts of the farm, where cheaper methods of irrigation can be applied to alfalfa, orchard, bush berries, potatoes, and other crops grown in wide rows for horse cultivation.

Truckers in the arid sections seem to favor a combination of spray irrigation and surface irrigation on the same field. The spray is used in the preparation of the seed beds, germinating seeds, and starting newly set plants. Later the crops are irrigated during the maturing and fruiting periods by the surface furrow or check methods. A portable spray equipment often meets these conditions most economically, because it can also be used for the irrigation of hot-bed and cold-frame crops.

Farm Conditions Adapted to Spray Irrigation.—Spray irrigation can be practiced to advantage on both light and heavy soils. By this method it is possible to apply evenly to sandy soils the small quantities of water which such soils will retain, without the loss of water by percolation which might occur with other methods. It is possible also to apply to heavy clay soils the small quantities of water required to soften such soils when they have baked after rains, and to apply water no faster than the soil can absorb it, thus preventing loss by surface run-off.

Lands to be irrigated should be drained as completely as possible of excess moisture. Many tile-drained fields are the most responive to crops under spray irrigation.

Spray irrigation is practically independent of the topography of the field and can be applied to land too rolling or rough for surface methods. It is, therefore, adaptable to the irrigation of side hills on which soils tend to wash or erode.

Amount of Water Required for Spray Irrigation.—As yet, the available knowledge on the amount of water required for spray irrigation is limited, because of the comparative newness of the methods and the lack of actual records on plants under a time test. In the humid regions amounts not exceeding ¼ in. in depth often are considered a sufficient application to seed beds and young vegetables, while in the case of maturing garden crops and strawberries ½ to 1 in. may be applied. It is probable that truckers in the humid region do not use more than 6 in. in a growing season and in many seasons 4 in. or less will supplement the rainfall sufficiently. More water is required for sandy soils than for clay. A crop like the spray-irrigated citrus groves of Florida may require as much as 3 in. per irrigation. Truck and citrus growers in the arid regions apply more water than those in the humid region, probably because of a large evaporation loss. In the arid region the truck farmer is inclined to make frequent applications—every 3 or 4 days—rather than to apply the extra amount of water required in large applications which will wet below the reach of the vegetable roots, while the citrus grower applies from 4 to 8 in. each time.

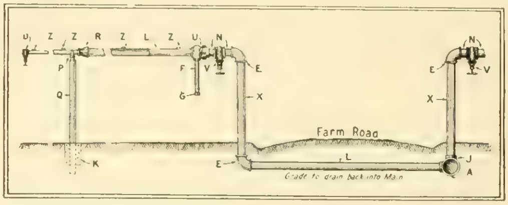

Fig. 2—Sketch Showing Typical Fittings for Overhead Nozzle Lines Connected to Main Feed Pipe and Method of Crossing a Farm Road.

A, main feed pipe; D, drain cock or cap; E, elbow; F, handle for turning nozzle lines; G, cap on handle; J, side outlet tee; K, concrete base for pipe post; L, nozzle line pipe; N, "long" nipples; P, pipe line hanger; Q, 1¼-in. pipe post; R, reducing cocket; U, turning union; V, brass gate valve; X, risers to nozzle lines; Z, nozzles.

For spray irrigation sufficient water to cover the land to a depth of 1 in. per week for humid regions and 1½ in. per week for arid regions is believed to be a safe estimate for designing purposes. A spray plant should be large enough to supply these amounts of water in a reasonable length of time. This is accomplished generally by installing the system of spray from one-fifth to one-half of the total acreage at one time, depending somewhat upon the type of distribution used and the available water supply.

All spray irrigation plants require power pumping equipment unless pressure can be supplied from an elevated source or municipal water works. To generate a spray requires a high-pressure pump producing 25 to 40

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*Cost of pumping estimated for a plant operating at 50 per cent efficiency against a total head of 150 ft., using gasoline as fuel. The amount of water pumped annually is assumed at 6 acre-inches as a typical duty of water in the Atlantic Coast States where spray irrigation is most extensively used. More arid sections require larger amounts.

TABLE I. BILL OF MATERIALS.

Amount.	Size. Inches.	Item.	Location.
1 run, 110 ft.	6	Black guaranteed wrought-iron pipe, cut to exact length, with allowance for 1 tee in each run	Main feed pipe.
12 runs, 50 ft. each	6	do	Do.
1 run, 25 ft.	6	do	Do.
30 runs, 30 ft. each	2	Galvanized wrought-steel pipe	Feed end east-and-west nozzle lines.
20 pieces, 7 ft. each	2	do	Nozzle-line risers.
7 pieces, 15 ft. each	2	do	Pipe under road, east-and-west lines.
3,500 ft.	1½	do	Do.
3,500 ft.	1¼	do	Do.
3,200 ft.	1	do	Do.
1,800 ft.	¾	do	Far end all nozzle lines.
700 pieces, 9 ft. each	1¼	Galvanized wrought-steel pipe, plain ends.	Pipe posts.
7	6 by 2 by 2	Black side outlet cast-iron tees	Main feed pipe.
6	6 by 2	Black cast-iron tees	Do.
7	2	Black malleable 90 ells	Bottom west risers.
20	2	Galvanized malleable 90 ells	Top east-and-west risers.
20	2	Galvanized long nipples	Feed end nozzle lines.
20	2 by 1½	Galvanized reducing sockets	Nozzle lines.
20	1½ by 1¼	do	Do.
20	1¼ by 1	do	Do.
20	1 by ¾	do	Do.
20	2	Standard brass gate valves	Feed end nozzle lines.
20	¾	do	Far end nozzle lines.
1	6	Standard iron-body gate valve	End of main.
20	2	Trade name, etc., turning unions	Nozzle lines.
3,160	No. —.	Trade name, etc., nozzles	Do.
700	No. —.	Trade name, etc., galvanized hangers.	Top of posts.

Note.—Main feed pipe made of one size full length, as full head of water to be pumped to farther fields for surface irrigation.

lb. pressure on the nozzles in addition to elevating the water to the field.

The Designing of Spray Irrigation Systems.—Every spray irrigation system can be divided into three parts, which must be considered in their proper relation to each other in the design of a plant. First, the distribution-pipe system, which applies the water directly to the crops through some type of nozzle; second, the main feed pipe, which conveys the water from the source to the distributaries; third, the pumping equipment, which lifts the water and develops the pressure, unless the water and pressure are obtained from a gravity or municipal supply.

The distribution system should be laid out to use the minimum amount of large pipe for both distributaries and main feed pipe. The laterals or nozzle lines should run in a direction which will give the least amount of obstruction to the cultivation of the field in the most efficient manner. The field should be laid off in irrigation blocks or units, a unit representing the area to be irrigated at one time. The unit should be of a desirable length for the kind of crops to be irrigated. Where possible, it is advisable to divide the field by the irrigation system into blocks which will make the estimating of acreages easy when arriving at the amount of seed and fertilizer required or determining yields. This is done usually by having a convenient fraction of an acre under each spray line or by having the crop rows a length which will make each rod or yard in width a known fraction of an acre.

To keep the cost of a spray distribution system as low as possible, yet obtain a good uniform pressure and distribution of water, the sizes of pipes must be proportioned properly. Each lateral or nozzle line must be proportioned in size according to the number and capacity of the nozzles used. The main feed pipe must be proportioned to carry the total amount of water to the most distant irrigation unit and then be reduced in size as the water is decreased by each nozzle line within the irrigation unit. The water required to run an irrigation unit determines the capacity of the pumping equipment.

Table I is a bill of materials for the typical farm (Fig. 1), and is given as an example of a form for obtaining quotations on spray irrigation equipment (see also Fig. 2). "Run" means a certain amount of pipe which will give a desired length when screwed together. Pipe less than 2 in. in diameter can be cut in the field, hence the actual number of feet required is stated for such pipe. "Location" refers to the location in the field. Nozzle lines are assumed to be 630 ft. long on each side of the farm road. Pipe posts are assumed to be set 18 ft. apart, and 9 ft. long, to support nozzle lines 6½ ft. above the surface.

Operating Results of Purification Works of Columbus, O.—The mechanical filtration plant of Columbus, O., was placed in operation in September, 1908. The comparative and average results of operation since that time are given as follows in the annual report of Charles P. Hoover, Chemist, in charge of the works:

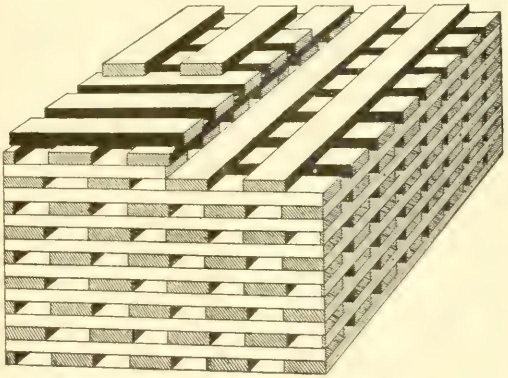
Year.	Volume of water softened and purified, million gal. per 24 hrs.	Total hardness, parts per million. River water.	Total hardness, parts per million. Filtered water.	Bacteria per cubic centimeter. River water.	Bacteria per cubic centimeter. Filtered water.	Turbidity. River water.	Turbidity. Filtered water.
1909	14.3	253	93	9,235	120	86	0
1910	15.2	270	85	9,335	24	37	0
1911	15.6	245	84	11,470	35	68	0
1912	17.5	252	74	19,210	11	84	0
1913	18.3	271	88	6,310	15	69	0
1914	18.4	297	79	6,331	14	54	0
1915	17.7	279	88	8,027	24	58	0
1916	19.8	279	110	1,182	24	85	0

Increased Water Supply Due to Industrial Demands.—In 1913 seventeen of the largest water consumers of Johnstown, N. Y., who were in the business of leather dressing, used a total of 49,846,215 gal. of water for that year, compared with its use during the year 1916 of 260,468,087 gal. or an increase of 366 per cent. These 17 services use one-third of the total water from the city's three sources of continuous supply.

TRICKLING FILTERS WITH WOOD BEDS.

An experimental trickling filter bed composed of wood laths has been in continuous use at Toronto, Ont., for 3½ years, and has given very satisfactory results. Filter beds of brush wood also have given excellent results. The experiments were conducted under the direction of Lt. Col. G. G. Nasmith, Director of Laboratories, Department of Public Health, Toronto, and are described by him in the Journal of the Royal Sanitary Institute, from which the following is abstracted:

The experiments were designed with the object of increasing the surface of the filter per cubic yard, and of allowing freer circulation of air than the ordinary types of filter-beds permitted. Wood was selected as the material lending itself best to the problem, and the first filter, 6 ft. square, was made of laths. The laths of the lowest layer were laid parallel to one another, the spaces between the laths being a little less than the width of the laths themselves. A second layer was laid on top of this and at right angles to it, with the same interspace. A third row was laid parallel to the bottom row, but in such a manner that the laths covered the spaces left between the laths of the lower series. In this way a filter 4 ft. in depth was constructed in which the sewage, in order to reach the bottom, had to flow over a very large surface of filter. Air could enter from all sides and the top through the regular channels provided; in fact, one can see right through this filter, so uniformly regular are the spaces.



Sketch Showing Arrangement of Wood Lath.

Sedimented city sewage was allowed to trickle over the surface of this lath-filter; in less than a month the filter was mature, and the results obtained thereafter exceeded all expectations. Where the standard type of stone filter, operated side by side with it as a control, treated 2,000,000 gal. of sewage per acre per day, the lath-filter treated 6,000,000 gal. and yielded a non-putrescible effluent. This lath-filter has now been in continuous use for 3½ years, and has never failed to give satisfactory results.

From these results it was argued that poles might give an even greater surface per unit of volume, because the poles would only come into contact along very narrow surfaces when built into a filter like the laths. Two such filters were built, each 6 ft. square and 6 ft. in depth; after maturing they yielded practically the same results as the lath-filter. They were, however, very difficult to construct; it was difficult also to obtain an even distribution of the sewage flow, and short circuiting of the flow was also liable to occur. This form was abandoned as not being of practical value. One pole-filter, however, was installed in 1914 at the city of Toronto Industrial Farm to treat the sewage from several hundreds of people. No provision had been made for the fact that sewage in small communities frequently comes in gushes, and consequently, as the bed was overdosed at some periods and had no work to do at others, the results were not satisfactory. These defects have recently been remedied.

A filter built of slabs of wood was discarded, as it was only capable of treating sewage at the rate of 3,500,000 gal. per acre per day. Finally, it was decided that brushwood, pressed into bundles, would make the ideal filter for filter beds, because it would provide the combination of a very large surface area and presence of air which is so essential.

When the town of North Toronto was annexed to the city of Toronto a few years ago, it had a system of sewage disposal, part of which consisted of three trickling stone filters, each 30 ft. in diameter. In the early spring of 1914 the stone was removed from one of these filters. Bundles of brushwood, cut from the woods near by, were made on the spot by means of a rough box-press, wired together, and placed in the filter until a depth of 4 ft. had been obtained. A space of 1 ft. was left between the brush-bundles and the wall, and a small space in the center so as to allow air to enter freely from the sides. The old revolving distributing sprinkler was then put into operation, the brush quickly became matured, and in two months it was treating sewage at the rate of 6,000,000 gal. per acre per day. A very high degree of nitrification has been obtained; the effluent has been uniformly stable; and the installation has proved to be a decided success. This brush-filter has now been in operation for two years, and has worked just as well in winter as in summer. Of course, it is always necessary to cover filters of every description in winter in Canada to prevent freezing. A brush-filter that was operated in the open to prove whether this would occur in the Toronto climate rapidly froze solid.

Comparative figures showing average analyses of raw sewage, activated sludge tank sewage and lath-filter sewage follow:

DEPARTMENT OF HEALTH EXPERIMENTAL SEWAGE DISPOSAL PLANT, TORONTO.

Average Analyses, June 20, 21 and 22, 1916.

	Free NH_3.	Alb. NH_3.	Nitrites and nitrates.	Bacteria per cc. 47°C.	red colonies. MacConkey, 37°C.
Raw sewage	16.0	7.58	2.66	1,453,333	563,333
Activated sludge-tank, 4 hours blowing 2 cu. ft. of air per gal. of sewage	8.9	1.9	12.3	5,690	700
Lath-filter, treating 4.5 gal. of sewage per acre per day	10.0	1.7	10.1	9,400	1,266

After 3½ years the lath-filter shows no signs of incipient decay, confirming the common experience that wood which is kept constantly wet does not decay. In both the lath and the brush-filter the wood is covered with slime, so that the wood is always soaked.

The advantages of the brush-filter may be summarized as follows: (1) Brush is cheap, and may be obtained almost anywhere; (2) skilled labor is not required in construction; (3) it does not sludge; the slime will frequently become quite thin after heavy rains when the sewage is diluted, though the efficiency of the filter is unimpaired; (4) the brush may at any time be removed and burned; (5) it is durable; a filter has now been in operation for over 2 years without showing any signs of decay; (6) the distribution of the sewage over the surface of the filter does not need to be very uniform; the general tendency is to redistribute itself in the filter meshwork; (7) it gives the maximum amount of surface, with a freer circulation of air in a unit volume of space; (8) it has proved to be a success when treating the sedimented sewage of a city on a large scale, and has treated three times as much sewage to the acre as the standard stone filter will treat.

Patents were applied for in the year 1914, in order to protect the city of Toronto until such times as the experiments should be completed. No rights or royalties are claimed, however, in connection with the process. In fact, it is hoped that the cheapness of the system will enable communities to install systems of sewage disposal in districts where the high cost of the accepted types of installation have been prohibitive in price.

TESTS OF ULTRA VIOLET RAYS FOR WATER PURIFICATION.

The employment of ultra violet rays, at the present time, is receiving considerable application in furnishing treated water for drinking purposes, in bottling works, in the sanitation of swimming pools and for the use of armies in the field. In France the method is said to be successfully applied to the treatment of municipal water supplies. Tests of ultra violet ray apparatus were conducted recently by Mr. R. R. Spencer, Assistant Surgeon, U. S. Public Health Service, Chicago. The results of these tests were given by Mr. Spencer in a paper presented March 13 at the annual meeting of the Illinois Section of the American Water Works Association, from which the matter that follows is taken:

A gravity and a pressure type of mercury vapor arc lamp apparatus were tested. In the gravity type the lamp is suspended in a baffled treatment chamber a few inches above the surface of the water, which in a thin film is exposed twice during its passage by the lamp. This type is operated at 110 volts and has a rated capacity of 120 gal. per hour.

The pressure type consists of a cast iron cylindrical shell with a quartz tube through its axis and containing an arrangement of baffled plates for the same purpose as those in the gravity type. The lamp is inserted within the axial quartz tube. A 220-volt lamp is required to produce a sufficient amount of ultra violet rays for treating 750 gal. of water per hour, the rated capacity.

Usually a fluctuation in voltage of 10 per cent or over is sufficient to extinguish the light. To prevent the passage of untreated water, each apparatus is provided with an automatic electrical arrangement controlling valves which will prevent the flow of water until the temperature of the lamp has risen sufficiently to produce an abundance of ultra violet rays and which will cut it off when for any reason the light goes out.

Each apparatus was operated in connection with a rapid sand pressure filter which clarified the water just before it entered the light chamber. It was at this point that all the raw water control samples were taken. In order to artificially contaminate the water the alum shunt-feed box on the filter was kept filled with rich broth cultures of B. coli and other bacteria. By this means enormous quantities of all kinds of organisms could be fed to the filter, which allowed nearly all to pass through to the ultra violet ray apparatus after the sand bed had once become thoroughly saturated with them. The raw water contained many more times B. coli than one ever finds in the worst drinking water.

The vast majority of all samples were collected while the apparatus was being operated in excess of its rated capacity.

Small Gravity Type Apparatus.

(Capacity, 120 gal. per hour.)

The following table includes a total of 142 samples, taken on 17 different days during a period of two months:

No. and kind of sample.	Average total count per c.c. on Agar at 37° C.	Average number of B. coli.
33 raw water	29,400	3.256 in 1 c.c.
109 treated water	12	1 B. coli in 15 c.c.

86 of 109 treated samples gave 0 B. coli in 50 c.c.
10 of 109 treated samples gave 1 B. coli in 50 c.c.
2 of 109 treated samples gave 2 B. coli in 50 c.c.
2 of 109 treated samples gave 3 B. coli in 50 c.c.
1 of 109 treated samples gave 4 B. coli in 50 c.c.
1 of 109 treated samples gave 5 B. coli in 50 c.c.
*7 of 109 treated samples gave 50 B. coli in 50 c.c.

*The last seven samples showing 50 B. coli in 50 c.c. were taken after the machine had been idle for one month and the raw water controls at the same time had at least 100,000 B. coli per c.c. and a total count of 150,000. If these seven samples are eliminated in figuring the average number of B. coli in the treated water, there would be only one B. coli in 175 c.c. instead of one in 15 c.c. as shown in the table.

Large Pressure Type Apparatus.

(Capacity, 750 gal. per hour.)

The following table includes a total of 330 samples, taken on 29 different days during a period of two months:

No. and kind of sample.	Average total count per c.c. on Agar at 37° C.	Average number of B. coli.
48 raw water	3,900	2,630 in 1 c.c.
282 treated water	7	1 B. coli in 103 c.c.

211 of 282 treated samples gave 0 B. coli in 50 c.c.
31 of 282 treated samples gave 1 B. coli in 50 c.c.
21 of 282 treated samples gave 2 B. coli in 50 c.c.

14 of 282 treated samples gave 3 B. coli in 50 c.c.
3 of 282 treated samples gave 4 B. coli in 50 c.c.
2 of 282 treated samples gave 5 B. coli in 50 c.c.

The bacteriological tests were performed, with slight exception, in accordance with the Standard Methods of Water Analysis of the American Public Health Association. The fermentation of lactose broth and the characteristic appearance on Endo was considered sufficient identification of B. coli.

A total of 391 treated samples were tested. Of these 53, or 13.5 per cent, did not come within the U. S. Treasury Department standard of permissible impurity, which requires that not more than one of five 10 c.c portion of each sample shall show the presence of organisms of the B. coli group. This appears to be a poor showing. However, it cannot be so considered when a comparison is made with the extremely polluted raw water control samples collected at the same time.

In the gravity type of apparatus 86 of 109 treated samples, or 78.8 per cent, showed no organisms of the B. coli group in 50 c.c., while the untreated water contained an average of 3,256 B. coli per cubic centimeter.

In the pressure type 211 of 282 treated samples, or 74.8 per cent, gave no B. coli in 50 c.c., while the untreated water was yielding 2,630 B. coli in 1 cubic centimeter. The great reduction is the more remarkable when one considers the actual time of exposure of the water to the rays is approximately 64 seconds in the large and 30 seconds in the small apparatus, when they are running at their normal rate.

The fact that spore-bearing organisms are somewhat more resistant to those rays than vegetative forms has been shown by von Becklinghausen. In the above outlined tests the lactose broth tubes would frequently show fermentation at the end of 48 hours. In such cases transfers invariably proved negative on Endo for B. coli. The organism that caused this result proved to be a strict anaerobe and was later identified as belonging to the B. Welchi group. It is believed that the appearance of such organisms in water is not of sanitary significance.

Conclusions.

The use of ultra violet rays in the purification of drinking water is relatively a recent procedure, and it is believed that the method is capable of further development, with a corresponding increase in efficiency. The method is especially recommended for treating water in circulating systems, in which the water may be exposed many times to the ultra violet rays. Such systems are now used for disinfecting water in swimming pools, hotels, industrial and other institutions. The chief advantage of this method of treatment over chemical methods lies in the fact that objectionable overdosage is impossible. Again, from the standpoint of potability, the water is absolutely unchanged, and hence in this respect is superior even to boiled water. Recently ultra violet rays have been recommended for sterilizing the drinking water on vessels traversing the Great Lakes. The fresh water of the lakes is very clear, and the turbidity that does occasionally occur consists mostly of heavy suspended matter and is easily removed by filtration.

The present forms of apparatus need considerable attention when in operation. Care should be taken to prevent an accumulation of grease or dirt of any kind on the quartz tube. Experience has shown that a very small amount of grease will obstruct the light sufficiently to allow many organisms to pass. Furthermore, the light chamber should be emptied if the machine remains idle for any length of time. This will prevent the growth of algae and other organisms which will obstruct the light when the machine is operated. There is no way to determine when the lamp fails to emit a sufficient amount of ultra violet rays to give a satisfactory water, except by collecting samples and testing the treated water frequently. Theoretically, as long as the lamp remains intact and the vacuum holds, no reduction in the amount of ultra violet emanation occurs. It is stated by the manufacturers that a lamp will wear out before its efficiency noticeably decreases. The proper construction of the lamp is of great importance, and considerable variations have been noted between individual lamps.

In the above tests, since the gravity type gave a higher efficiency than the pressure type, and inasmuch as any lamp operating at a higher voltage is known to emit a larger amount of ultra violet radiation, the use of lamps at a higher voltage, combined with the gravity system, suggests itself as a reasonable line of development.

In regard to cost, the method is not expensive when treating quantities of water of 30,000 gal. or less per 24 hours. For municipal supplies, using several million gallons per day, the expense is considerable, and probably prohibitive.

VALUE OF KUTTER'S "N" FOR METAL FLUMES.

Investigations were made in 1915 by the U. S. Reclamation Service to determine the value for metal flumes of the coefficient "n" in Kutter's formula. The results are given in the January Reclamation Record, from which the following is taken:

In making each test the length of flume was carefully measured and intermediate stations were established at intervals of 10 to 25 ft., depending upon the length of the flume. Maximum and minimum elevations of the water surface at the sides and in the center were taken at the beginning and end of the reach tested and the average elevations at the sides and center were taken at each intermediate station. All elevations were determined by levels run from a bench mark established near the flume. The depth and area of the cross-sections were not based on the theoretical section, but were measured at each station and the hydraulic properties used were averages for the entire reach. The water surface slope was in all cases corrected for velocity head. The discharge was determined by current meter measurement made immediately before or after taking the elevations of the water surface or by reading the gage at some nearby well-established rating station.

The results indicate that 0.012 is a fair average value for "n" in flumes with smooth interior, and that 0.013 may be considered amply safe for design. The only determination which appreciably exceeds this was made on a flume which has a slight curve in alignment, beginning 17 ft. from the lower end. This may have impeded the flow sufficiently to affect the determination of the coefficient, though there was no visible indication of it.

The results obtained are tabulated as follows:

FLUMES WITH SMOOTH INTERIOR (COUNTERSUNK JOINTS).

Size.	Length tested (feet).	Discharge (second-feet).	Slope of water surface.	Value of "n."
Uncompahgre Project—				
No. 120	197	62.5	0.003604	0.0122
168	300	20.8	.0003	.0139
192	350	36.5	.000230	.0117
204	250	177	.00111	.0131
204	250	184	.00094	.0121
204	230	127	.00074	.0125
204	220	73.9	.000454	.0103
North Platte Project—				
No. 108	525	39	.00118	.0097
108	525	14.5	.00118	.0097
120	690	40	.000888	.0117
120	690	18	.00061	.0121
132	400	56	.00126	.0087
132	400	45	.00098	.0105
156	600	95	.00129	.0105
156	600	78	.00135	.0107
156	600	68	.00115	.0106
156	600	44	.00116	.0121
204	300	150	.00104	.0129
204	300	105	.00119	.0123
204	300	[illegible]	.00121	.0130
			Average,	0.01145

FLUMES WITH PROTRUDING JOINTS (MAGINNIS TYPE).

Size.	Length tested (feet).	Discharge (second-feet).	Slope of water surface.	Value of "n."
Uncompahgre Project—				
No. 108	140	42.1	0.002786	0.0175
North Platte Project—				
No. 132	[illegible]	[illegible]	.00157	.0188
132	590	23	.00163	.0178
132	590	17	.00154	.0180
132	490	75.8	.00202	.0202
			Average,	0.0185

The much higher value of "n" for flumes with protruding joints will be noted, the average from the few experiments made on this type being 0.0185. Six experiments on No. 120 flume made on the Uncompahgre project in former years gave an average value of 0.0207. These previous experiments are of somewhat doubtful accuracy, but may properly be used to add weight to a cautionary statement that it is not safe to use a value of "n" much smaller than 0.020 when computing the capacity of a flume of the protruding-joint type.

THE SEWAGE DISPOSAL WORKS OF MASON CITY, IA.

Contributed by Robert F. Gayton *

The sewage disposal plant now under construction at Mason City, Ia., consists of pumping station, Imhoff tanks, dosing tank, percolating filter, humus tank and sludge beds, and caretaker's cottage. The entire plant covers approximately 3 acres. It is situated on Lime Creek, a small, clear stream having a minimum volume of 15 cu. ft. per second during the dry season. Because of this low rate of flow, the pollution formerly was very marked, giving rise to very offensive odors, and causing many complaints by farmers lower down the stream. After considerable study the city adopted the Imhoff type of disposal.

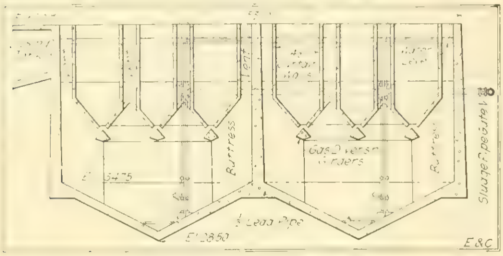


Fig. 1—Section of Imhoff Tank.

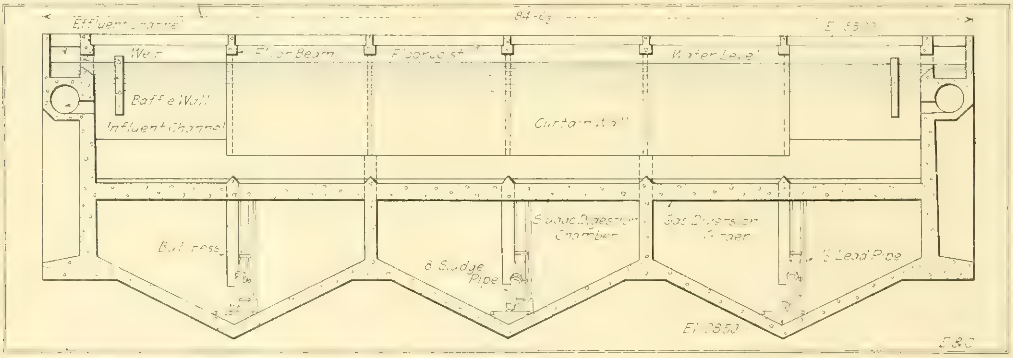


Fig. 2—Longitudinal Section of Imhoff Tank.

The pump house, 21 ft. x 22 ft. and 18 ft. deep, divided into screening chamber and pumpage tank, is equipped with three vertical centrifugal pumps having 8-in. suction with 6-in. discharge, electrically operated capable of working against a 40-ft. head. The pumps are automatically operated by float switches. Before the sewage enters the pump well it passes through a series of screens made up of 3/8-in. x 4-in. x 72-in. wrought iron bars set 2⅛ in. apart. The screens are set at an angle of about 60° with the horizontal. As the sewage contains no storm water, no grit chamber is provided for.

The type of Imhoff tank is seen in the accompanying figure. It is a 2-story tank having a total depth of 26½ ft., with an over-all measurement of 53 ft. x 84 ft. x 6½ ft., and is a double tank containing six sludge digestion chambers. The sludge is discharged through an 8-in. cast iron pipe from a head obtained by taking the sludge pipe out at a point 6½ ft. below water level.

The curtain walls which form the troughs and gas vents are concrete 4½ in. thick reinforced by ¼-in. rods set 12 in. on center vertically and 6 in. on center horizontally. The humus tank curtain walls have a design identical to the curtain walls of the Imhoff tank. In the opinion of the author, who is the engineer in charge, the construction of these curtain walls would have been much simplified had the design been a No. 26 gage self-centering reinforcement built up to a thickness of 2 in. by the use of the cement gun, the gunite being a 1:3 mix with sufficient hydrated lime to obtain a smooth mortar.

It will be seen from Figs. 1 and 2 that the form work necessary for the 4½-in. curtain walls is a difficult and costly proposition. The walls are narrow and deep, making the spading of the concrete nearly impossible. In pouring these walls the mixture was made very wet. Later, on removing the forms several large holes were found in the concrete caused by the leakage of the form work. It was estimated that the form work for the humus tank curtain walls required 10,000 ft. of lumber and there are approximately 72 cu. yd. of concrete in them.

From the Imhoff tank the sewage flows to the dosing tank. The capacity of this tank is approximately 26,000 gal. It is discharged automatically by a 24-in. siphon. The bottom of the tank is tapering, giving a longer discharge under higher heads throughout the dosing tank period. The siphon is so placed that it siphons directly over the top of the filter wall.

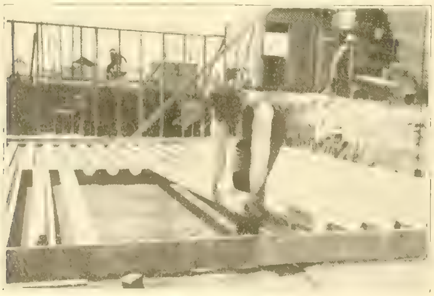


Fig. 3—Forms for Drains in Filter.

Fig. 4—Floor of Filter.

The percolating filter has an inside measurement of 176 ft. x 253 ft. and is enclosed by an 8-in. reinforced concrete wall. A 4-ft. x 6-ft. arched flushing gallery extends down the entire length of the filter. The under-

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*Assistant City Engineer and Engineer in Charge of Construction.

drainage system slopes in two directions, 6 in. from the flushing gallery to the collecting channels on either side of filter, and a 2-ft. slope lengthwise toward the humus tank. The filter floor is constructed of 1:2:4 concrete, reinforced by a steel mesh. Its total thickness is 8 in., including the 3-in. drain. The illustrations show the concrete floor and the forms used in the construction of the drains. These forms are built up of 2-in. x 4-in. and 2-in. x 6-in. boards. A set of 130 was used continuously and placed by two carpenters. The surface of the drain is smooth and even in slope. On the top of the drains is the false floor, consisting of vitrified brick set in mortar and spaced 1 in. apart. The 7 to 9 ft. of filter medium consists of a screened hard lime rock of such size as is held by a 1-in. ring and passed by a 2½-in. ring.

The distribution system consists of cast iron pipe laterals placed near the top of the filter medium, provided with 3-in. risers 9 in. long. The nozzle is of the Taylor square nozzle type 11 ft. on centers. The filter discharges its effluent into the humus tank.

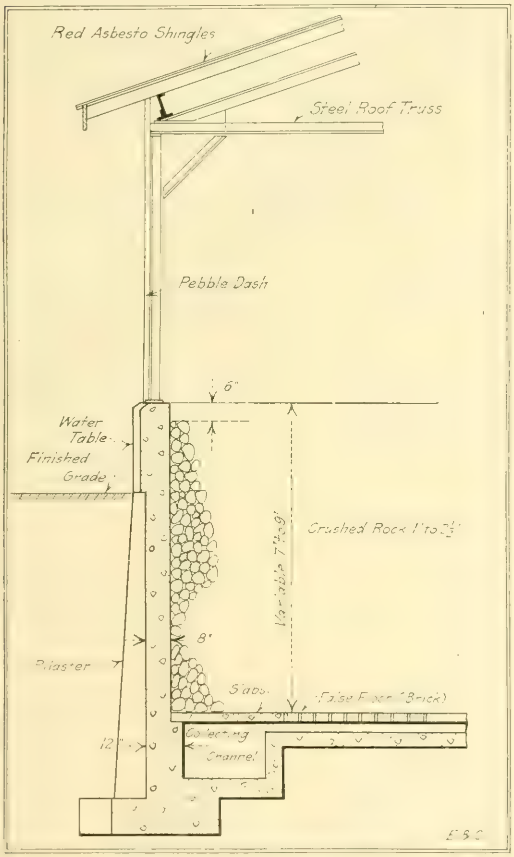

Fig. 5—Section of Wall of Percolating Filter.

The features of design of the humus tank are identical to those of the Imhoff tank. The humus tank has a total depth of 20¼ ft. Is a 2-story tank measuring 42 ft. 7½ in. x 79 ft. and is divided into three separate settling chambers. The sludge is withdrawn by three horizontal electrically operated centrifugal pumps, each having a capacity of 40 gal. per minute.

The final sewage effluent is conducted over a weir into the outfall sewer and into Lime Creek.

The sludge beds, eight in number, cover an area of 64 ft. x 142 ft., enclosed by a 12-in. reinforced concrete wall 3⅓ ft. high. The sludge bed medium has an average depth of 18 in. It consists of a screened crushed hard lime rock graded ½ in. to 2 in., upon which is a 3-in. layer of filter sand. The beds contain 200 ft. of 24-in. gage industrial track, upon which is run metal tipping dump cars of 1-yd. capacity used in hauling away the dried sludge.

The caretaker's cottage is a 5-room modern house situated to one side of the disposal plant grounds.

With the exception of the sludge beds, all units of the entire system are covered. The buildings are finished outside with pebble dash and roofed with red asbestos shingles.

The plant is designed to take care of 30,000 people and will cost $155,000 when complete. This includes the garbage incinerator constructed on the same grounds.

CONSTRUCTION AND OPERATING RESULTS OF INFILTRATION SYSTEM OF WATER SUPPLY OF PARKERSBURG, W. VA.

For the past 5 years the city of Parkersburg, W. Va., has been obtaining its water supply from an infiltration system composed of strainer pipes laid in the bed of the Ohio River and overlaid with a bed of washed gravel and sand. This was the first installation on a large scale of the Smith infiltration system. A description of the construction of this system together with some operating results are given by Mr. William M. Hall, M. Am. Soc. C. E., a member of the Parkersburg Waterworks Commission, in a paper* in the January (1917) Proceedings of the American Society of Civil Engineers, from which the following is abstracted:

As there had been considerable skepticism regarding the successful working of the Smith system, no similar works of comparable size having been in operation, the contract was made unusually exacting. Only 45 per cent of the value of work done was paid on monthly estimates, the remainder being retained until 30 days after the test period of 364 days after the beginning of successful operation, as guaranteed. The contractor made the following guaranties for the system:

1—The capacity to be 170,000 gal. per hour.
2—The supply to be satisfactory to the Water Works Commission and the Board of Affairs, for domestic and industrial uses.
3—The water to be of pleasing appearance, practically clear and colorless, and to contain not more than 5 parts per million of turbidity.
4—With 3,000 bacteria per cu. cm. in the raw water (or higher), the filtered water to contain not more than 3 per cent of that number; with less than 3,000 per cu. cm. in the raw water, the filtered water to contain not more than 100 per cu. cm.; counts to be on agar plates incubated at 20° C., for 48 hours.
5—Filtered water to contain on an average not more than 30 parts per million of total hardness in excess of Ohio River water.
6—Iron in solution not to exceed 0.7 part per million.
7—The foregoing requirements to be shown by daily tests covering a period of 364 days from the date of beginning operation.

In case of failure to comply with the guaranty, the city was under no obligation to pay the retained 55 per cent, and the completed plant was to become the property of the city.

Under the contract with Mr. L. E. Smith three units were completed and put in service on Nov. 12, 1911. The other two units were completed and put in service on Dec. 15, 1912. The plant has been in continuous operation ever since, except for 4 days during a flood which broke the former highest record by 5 ft., and thereby partly submerged the boilers and engines.

Fig. 1 shows the arrangement of the pipes in the infiltration system, and illustrates the appearance of the units while being laid.

The site of the plant is on the lower end of the bar at the foot of Vienna Island, at a point where the natural top of the bar forming the bed of the river is about 1 ft. below the low water level. By inquiry, and the examination of Government hydrographic maps made about 10 years previous to the preparation of the plans, it was concluded that this bar had been practically stable for many years.

The system of five units of filters was placed by using two cofferdams of the ordinary box type common on the Ohio River lock and dam construction; and the suction pipes to the power house were laid in an open trench, with the excavated material banked on each side. The work was done during the low water seasons of 1911 and 1912, with the top of the coffer from 7 to 8 ft. above low water.

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*"The Water Supply of Parkersburg, W. Va.," Proceedings Am. Soc. C. E., Vol. XLIII, No. 1, pp. 27-66.

At this point the fluctuation of the water is about 58 ft., and stages up to 40 ft. are of annual occurrence. Coffer No. 1, enclosing Units 1 to 3, was built and removed in 1911, and Coffer No. 2 in 1912.

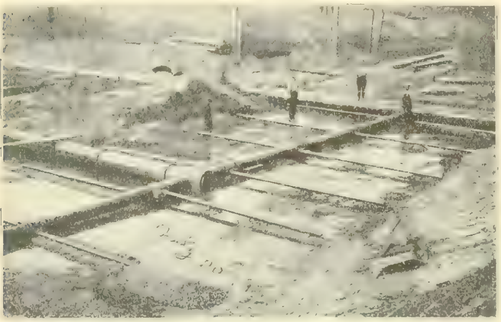
Fig. 1—Arrangement of Pipes for Infiltration System.

In the unwatered coffer the excavation for the pipes was made to 5½ ft. below low water. On the floor thus formed a 6-in. layer of gravel was placed, on which the pipes were laid and covered with 12 in. of gravel; on the gravel a 3½-ft. layer of clean washed sand was laid, bringing the top of the sand to within about 6 in. of the low water line, or a few inches higher than the natural surface of the bar.

The infiltration system of five units thus formed is 110 ft. wide and 656 ft. long (1.65 acre), and is 5 ft. deep. The gravel was the washed and screened Ohio River product which passed a 1½-in. mesh, and with the sand removed. The sand was taken from the Ohio River and sacked, and is fairly sharp and coarse. The filter thus constructed lies in a natural bed of sand of great dimensions. It is Mr. Hall's opinion that a very large percentage of the water drawn is taken from the sand bed, possibly a larger part than from the open river.

Each unit of the filter system contains 32 brass strainer pipes, 16 ft. long and 5 in. in diameter, or 160 pipes in the first units. Each pipe is perforated with 9,400 V-shaped slots, 1⅜ in. long and about 1/70 in. wide. From each unit to the gate chamber there is an 18-in. cast iron suction pipe, each of these pipes forming a small reservoir. They are connected with the pumps by one 24-in. cast iron suction pipe. This arrangement prevents serious trouble by the production of the vacuum in the suction pipes, with the resulting flow through the filtering material at an undesirably rapid rate.

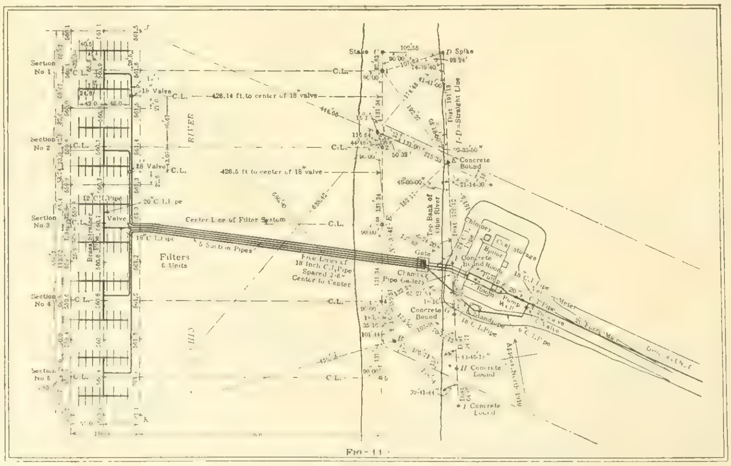

Fig. 2—Layout of Infiltration System and Pumping Station of Improved Waterworks System of Parkersburg, W. Va.

The expense of operating the filters in 1915, including flushing the five units 73 times, is estimated by the superintendent's office as $673. The average quantity of water used for each unit at each flushing is 40,000 gal. Although the tank capacity is 60,000 gal., it is the custom, in operation, to use 40,000 gal. at each flushing. The cleaning and flushing is practically all the expense which has been incurred in excess of pumping out of the open river. The time required to pass the 40,000 gal. through a filter is from 15 to 20 minutes. When pumping out of the open river with the old plant, some trouble was caused by ice, leaves, etc., but it is believed that the cost of pumping from the filters and keeping them cleaned is no greater than that of pumping from the open river.

The maximum pumped in one week in 1915 averaged 3,760,000 gal. per day and 154,166 gal. per hour. For 2 weeks after the great flood of 1913, the average pumpage and consumption exceeded 5,500,000 gal. per day.

The water has shown a little turbidity about three times, at river stages of about 45 ft.

From May 1, 1913, to Jan. 31, 1914, daily tests of the water were made under the direction of the Commission by Dr. L. O. Rose in his laboratory at Parkersburg. The report shows that the quality of the water produced by the filters conformed in every respect with the terms of the contract.

A recent report of it, prepared for the city of Wheeling, W. Va., has questioned its being of the highest standard. Since March, 1916, samples of water have been shipped monthly to the West Virginia State Bacteriologist, at Morgantown, W. Va., for test. Of about 14 shipments, several, when tested after standing a day or more, have been reported "unsafe." From Feb. 15 to Oct. 27, 1916, Dr. Rose tested 38 samples and found bacilli coli present in 11, and absent in all the others. For each of these 11, 2 tests were made of 1 cu. cm. and 10 cu. cm. each. In 3 of the samples coli were present in both tests, and in the other 7, it was absent in the 1 cu. cm. Of the other 27 samples, the two tests were made for 19 of them and only the smaller quantity for the other 8.

On account of these reports, early in September, 1916, Samuel Gray was engaged to have all the filter beds examined and cleaned. He assigned G. H. Leland, M. Am. Soc. C. E., to carrying out this work personally and Mr. Leland was engaged in doing this for nearly a week. At several places there were holes in the sand and gravel covering. The holes were from 5 to 10 ft. in diameter, and were formed like craters. They extended down to within

1 or 2 ft. of the level of the brass strainer pipes. The work done under Mr. Leland's supervision consisted of stirring the deposit on top of the filter beds with a powerful force pump, at the same time giving each section numerous back-flushings, and thereafter filling the holes with fresh gravel and sand. In the 10 samples tested by Dr. Rose since that work was done, no coli were found. Of these 4 were tested in both 1 cu. cm. and 10 cu. cm., as previously explained, and the other 6 in only the smaller quantity.

Mr. Hall is of the opinion that tests should be made at regular intervals, weekly or more frequently; but, on account of the confidence in its quality, it appears that such an important work to safeguard the health of the community has not been done regularly.

Under date of June 10, 1913, Mr. I. L. Birner, Bacteriologist, certified to Contractor Smith, after a series of tests in a laboratory at the pumping station, that:

> An examination of the results of 400 separate analyses of the filtered water at the Parkersburg filtration plant, made between January 23 and June 4, 1913, covering a widely varying set of conditions, from a river stage at 5.8 to 58.9 ft., and with a river turbidity varying between the extreme limits of 15 and 1,950 parts per million, shows a clear water, with an average total hardness of 10.5 parts per million in excess of the river water; the total iron in solution, of the filtered water, was 0.19 of one part per million, against an average of 5 to 16 parts in the river, and a bacterial removal, or bacterial efficiency, of 98.28 per cent.

Thus far, the system has been entirely satisfactory to the citizens. Its success has been fully equal to the most sanguine hope of Mr. Hall when, as a commissioner, he voted for its adoption. However, he realizes that the experimental stage is not past.

Three units are now ending their fifth year of service, and the other two their fourth, with comparatively little indication of failure in quantity, or in the quality of the water.

However, Mr. Hall states that it is only a question of years when the sand and gravel over the strainer pipes will have to be replaced by fresh clean gravel and sand; the principal question being the number of years before this will become necessary in order to maintain the good quality of the water. He is also impressed with the great importance of vigilance and care in its operation, and of systematic daily or weekly tests of the water.

Approximate Cost of Reservoirs Per 1,000,000 Gal. Water Stored.—The following tabulation from the report of the Water Commissioners of Hartford, Conn., C. M. Saville, Chief Engineer, for the year ending March 1, 1916, gives comparative figures of size, capacity and cost of various reservoir developments similar to those now being carried out by Hartford:

Supply.	Reservoir.	Area flowed, acres.	Average depth, feet.	Storage, million gallons.	Cost per M. G. stored.
Hartford	Nepaug	851	34	9,560	$ 130*
Boston	Wachusett	4,195	46	63,068	145*
New York	Ashokan	8,180	48	128,000	155*
Salem and Beverly	Lawrence Station	4,430	7.6	10,900	250†
Hartford	Richards Corner	137	21	3,000	255†
Salem and Beverly	Topsfield Station	2,480	9.8	7,900	265†
Hartford	Reservoir 4	168	11.1	601	290*
Boston	Reservoir 3	253	14.3	1,180	360*
Boston	Sudbury	1,220	18.2	7,254	395*
New York	Kensico	2,218	40.0	29,000	395*
Cambridge	Hobbs Brk.	370	13.1	1,500	400†
Hartford	Reservoir 2	45	19.3	284	420*
Hartford	Reservoir 3	26	17.2	146	460*
Hartford	Reservoir 5	32	7.5	83	570*
Boston	Ashland	167	26.0	1,116	575*
Boston	Hopkinton	185	25.2	1,520	600*
Hartford	Reservoir 6	141	16.1	765	785*
Boston	Reservoir 2	131	12.1	530	880*
Boston	Reservoir 1	143	6.2	288	895*
Hartford	Reservoir 1	32	14.0	146	1,560*

* From records. † Estimated cost.

Cost of Meter Testing at Detroit, Mich.—The cost of meter testing at Detroit, Mich., for the year ending June 30, 1916, according to the report of the Board of Water Commissioners, was as follows:

Sizes	Number.	Flows, in.	Cost.	Average.
⅝-inch	11,505	Full to 1/16	$ 977.99	$0.08½
¾-inch	5,650	Full to 1/16	480.28	.08½
1 -inch	750	Full to 1/16	105.12	.14
1½-inch	111	Full to ⅛	53.60	.47
2 -inch	102	Full to ⅛	47.98	.47
3 -inch	21	Full to ⅛	44.18	2.10
4 -inch	13	Full to ⅛	27.36	2.10
6 -inch	6	Full to ⅛	12.62	2.10
	18,161		$1,749.13	

METHOD OF THAWING FROZEN WATER SERVICE CONNECTIONS AT ST. PAUL, MINN.

A gas engine electric generator set mounted on a motor truck trailer is used by the Bureau of Water of St. Paul, Minn., for thawing frozen water service connections. The arrangement was installed under specifications prepared by Mr. G. O. House, General Superintendent of the Bureau, and was described by him in a paper presented at the recent convention of the Minnesota Engineers' and Surveyors' Society.

The engine is a 4-cycle gas engine designed to run at 1,000 revolutions per minute at full load. It is direct connected by a leather link, flexible coupling to a generator.

The generator is of the direct current type, having a rating of 20 kw., producing 500 amperes at 40 volts. For the control of the generator a switchboard is installed, upon which are mounted indicating electrical instruments, together with a regulating rheostat, designed to regulate the voltage generated by the generator between zero and 40 volts. In addition to the engine, generator and switchboard, there is also a reel installed on the truck, mounted on a steel frame. This reel carries 500 lin. ft. of 300,000 C. M. extra flexible, insulated copper cable, in 100-ft. lengths.

The trailer is a Troy trailer of the reversible motor truck type, having a capacity of 1½ tons. The generating equipment and reel is secured to a steel frame, so that the entire equipment as a unit can be removed from the trailer in the spring and permit the trailer to be used during the summer season for any other purpose.

The procedure in thawing out a frozen service pipe is about as follows:

The trailer is attached to a motor truck and hauled to the location of the frozen service pipe. A sufficient amount of cable is then unreeled to reach from the generating apparatus to the basement of the house, and also another line to reach from the generator to the nearest fire hydrant. One end of the first cable is attached to the positive terminal of the main switch, and the other end attached to the service pipe on the street side of the meter in the meter box. The second cable is attached to the negative terminal of the main switch and to the revolving nut on the top of the nearest fire hydrant. The gas engine is then started and brought up to speed with the main switch open. The main switch is then thrown in and by means of the rheostat, the generator is regulated to give about 400 amperes at zero to 5 volts. After running at this point of regulation for about a minute, the voltage is raised to about 75 per cent of the capacity of the machine, and at this rate it is seldom necessary to continue furnishing current for more than 3 minutes. Most service connections are relieved of the ice obstruction in 2 minutes. In a few instances with large pipe and serious freezing, it has taken 15 minutes to remove the obstruction.

During the winter of 1916, 61 connections were thawed out and thus far in 1917 the machine has been used in 70 cases. It has operated with perfect satisfaction and a case has never yet been found where relief could not be given.

In the winter of 1916, which was the first season service was given by the machine, the Bureau attempted to charge for the actual cost of the use of the machine, including labor, supplies, interest and depreciation. It became evident that this method was not fair, because the owner of property a long distance from the storeyard of the Water Department was compelled to pay considerable more for the service than one who lived within a few blocks, so that this year the Bureau is charging a flat rate of $5 per service which is payable in advance.

The daily per capita consumption of water at Duluth, Minn., in 1916 was 81.86 gals. The cost of supplying the water, figured on operation, maintenance, depreciation and interest on bonds, was $86.31 per 1,000,000 gal.

OPERATION OF SOME OF THE MORE COMPLETE SEWAGE DISPOSAL PLANTS IN ILLINOIS.

The need of intelligent operation of sewage disposal works is well brought out by Mr. M. C. Sjoblom, Assistant Engineer, Sanitary Engineering Bureau of the Illinois State Boards of Health, in a paper presented at the recent meeting of the Illinois Society of Engineers. In his paper, which is reprinted below practically in full, Mr. Sjoblom gives the results of his observations at 10 of the more complete plants in the State. Eight of these were visited during January or February, and thus were observed under winter conditions, while the remaining two were visited during the past fall. In all cases the installations provide for preliminary treatment by means of 1 or 2-story tanks, and final treatment through intermittent sand filters, sprinkling filters or contact beds.

Three of the places visited, namely, North Chicago, the Naval Training School, and Fort Sheridan, are located along the north shore, and discharge their sewage into Lake Michigan. As several of the north shore towns obtain their public water supplies from the lake, the desirability of a highly purified sewage effluent is assumed.

All of the remaining towns, namely Chicago Heights, La Grange, Downers Grove, Barrington, Harvard, Pana and Olney, discharge their sewage into small inland streams which in most cases become dry or practically dry in the summer months, when the need for dilution is greatest. All these cities have been forced through law suits or threatened law suits, by injured riparian owners, to install their present extensive sewage disposal works.

Practically none of the towns visited have organized sewer departments, and the responsibility for the care of the sewerage system and sewage treatment works falls on the village Council as a whole, or on a part of its members. Two of the cities have engineers who superintend largely the operation of the treatment works, but even here the work is apt to be hampered by financial obstacles, and by having to accept such help as the Council will provide.

In the majority of the towns there seemed to be a general feeling that the duties of a caretaker of a well designed sewage treatment plant are rather unimportant, and that the plan requires but a small amount of attention occasionally. The operation of the plant has therefore in most cases been added to the duties of the local policeman or street commissioner, who as a general rule can give it only a fraction of the time and attention necessary to obtain a proper effluent.

In a majority of the plants visited there were evidences of neglect on the part of the caretaker and corresponding inefficiency of operation. In one instance, however, the reverse conditions were found, too much unintelligent attention having prevented the plant from operating at its maximum efficiency.

Before taking up the unsatisfactory features of design and operation at some of the plants, it might be of interest to note that out of the 10 plants visited not more than three appeared to be properly cared for, and to be giving satisfactory results in a general way, while in one of these the filter area is so limited that less than half the sewage can be given secondary treatment. A discussion of interesting features at various plants follows:

Barrington has a combined system which affords house sewerage facilities for only a small portion of the population. The outfall sewer consists of a 10-in. inverted siphon having its invert about 5 or 6 ft. below the flow line in the tanks which constitute part of the treatment works. Based on measurements made of the dry weather sewage some time ago, the velocity of flow through the siphon is negligible and during the greater portion of the time probably does not exceed ½ to ¾ ft. per second. Consequently organic wastes settle out in the siphon during normal flow only to be washed later in a septic condition into the screen chamber.

The screen chamber was found to be completely filled with a slimy dark sludge which all but shut out the flow into the Imhoff tank. As the Imhoff tank is installed largely for the purpose of keeping the sewage from becoming septic, the object sought is thus defeated by the sludge in the screen chamber.

At North Chicago, the plant consists of two septic tanks, a dosing chamber, sludge bed and trickling filters. During one day per week the sewage is by-passed directly into the small creek ordinarily receiving the filter effluent and the contents of the tanks, including the sludge which has accumulated during the remainder of the week, it slushed directly into the same stream. The cleaning of the tanks requires the services of two men for a day each week. It is thus seen that the plant does not serve the purpose for which it was installed, not through lack of attention or faulty design, but through unintelligent and misdirected energy.

The other extreme was found at Downers Grove, where the tank has not been cleaned for over six years, and the retention period has been reduced until the crude sewage with its fresh suspended and floating solids pass directly through the tank. The plant here includes a septic tank, a dosing chamber and several small trickling filter units, but owing to the freezing of the dosing apparatus which is rather complex in construction, only the tank is now in operation, and the crude sewage is discharged directly into the small creek which ordinarily receives the filtered effluent.

In all three of the towns where 2-story tanks comprise a part of the treatment works, it was found that large quantities of scum are permitted to accumulate in the sedimentation channels. At Olney this trouble arose from the fact that the plant is not provided with a means for the removal of sludge, and the authorities through lack of knowledge as to the principles of operation, had permitted the sludge to accumulate until it filled the tank above the slots. The sedimentation channels acted therefore as poorly arranged septic tanks.

The dosing apparatus in practically all of the plants appears to cause the attendants the greatest amount of trouble and worry. This apparatus, though supposed to operate automatically, needs daily attention, as there is no warning given when a siphon is going to lay off and if not attended to regularly the flooding of some of the filter units occur. Almost every plant attendant interviewed told of difficulties experienced in learning to remedy siphon disorders.

None of the intermittent sand filters in the towns visited recently was in operation, due to the cold weather, and only one of the plants including trickling filters or contact beds, namely that at La Grange, was operating to give satisfactory treatment to all of the sewage. At Chicago Heights the contact beds are probably operated as efficiently as possible, under existing conditions, but owing to their limited area and the inadequate size of the dosing apparatus which cannot handle all of the sewage, at least one-half of the sewage is passed directly from the septic tank to a nearby creek which receives the filter effluents.

In the cases where the trickling filters or contact beds were not operating properly, some of the difficulties were as follows:

At North Chicago only a portion of the filter area was in use, as one of the dosing siphons was out of repair. At the Naval Training Station the trickling filters were completely submerged, due to the sewage in the effluent troughs being frozen. At Fort Sheridan the nozzles on several of the risers in the sprinkling filters were missing, thus permitting practically the entire flow of sewage through the few uncovered risers, and little if any through most of the nozzles. At Downers Grove, which has already been referred to, the trickling filters were out of commission, due to the freezing of the dosing apparatus, while at Pana only about half the distributing troughs over the trickling filters were receiving sewage.

In all of these cases the sewage disposal works represent large investments by the communities they are built to serve. In several instances, however, little if any better results are being accomplished than would be possible with a sedimentation tank alone, if intelligently operated.

In not a single place visited were there any evidences of attention being directed toward beautifying the grounds, except so far as keeping the weeds cut down improves appearances. This means that the plants must of necessity be eyesores to those passing by, or to those living in the neighborhood, and harmonize well with the mental picture the average citizen probably has of a sewage disposal plant. It is only too true also, that in most cases this uncared for appearance of the surroundings is reflected largely in the works themselves.

Another feature which should be provided, but which is almost invariably lacking, is a shed or small building in which the attendant can find shelter during disagreeable weather, and in which the few necessary tools can be kept. In several cases it was observed that the attendant had to kick around in the snow near the tank, in order to locate some tool to be used in opening manhole covers. A building of this kind could well be used as a laboratory in which simple analyses could be made, as will doubtless be required in the time to come.

The present haphazard manner in which most of these plants are operated is indeed lamentable, but the blame for this state of affairs can probably not be laid to any one person or department. It appears, however, that those chiefly to blame are the municipal authorities, who, through desire to keep down expenses, or more often through ignorance, simply instruct the policeman or street commissioner to care for the plant and then apparently feel that the responsibility has been removed from their shoulders. In a majority of these cases the officials seldom if ever visit the plants, and when complaints are made regarding nuisances, often fall back on the statement that their plant is one of the most complete in the neighborhood, and that they understood that the plant was operating splendidly only a short time before.

To what extent if any the engineer is to blame for this state of affairs is difficult to judge. If one is willing to take the word of some city officials or plant attendants, however, it appears that quite often the engineer has given little if any instructions as to the importance of careful supervision.

Of course engineers who design the plants realize that proper care of the works is of the greatest importance and it is quite probable that they try to impress this fact upon the proper officials. It might not be amiss, however to suggest that more emphasis be given this point, and that engineers provide one or more framed instruction sheets giving in as simple form as possible detailed directions for the operation of the plant.

Where faithful and conscientious attendants are maintained they often give their work considerable thought and the plants are operated quite efficiently. As this state of affairs is the exception to the rule, however, it appears that some means should be devised which would provide for the intelligent operation of all plants installed. To this end it might be well to suggest that the city officials in engaging an engineer to design sewage treatment works also retain him to take charge of its operation for a year or more. In this way some man in the community could be trained in the duties connected with the plant. Another plan which might be practical consists in having the communities engage some competent engineer to make occasional visits to their respective plants and to see that they are being properly operated.

Forty-three Gal. Per Capita Water Consumption.—The water consumption at Dover, N. H., averaged 43 gal. per day per inhabitant in 1916. Figures for the last four years follow:

Year	Population census 1910	Yearly consumption	Average daily consumption.	Gals per day each inhabitant.
1913	13,247	186,002,000	509,722	38.4
1914	13,247	201,527,000	553,122	41.7
1915	13,247	187,147,000	512,636	38.7
1916	13,247	208,475,000	570,875	43

SOME NOTES ON THE OPERATION OF THE MIRAFLORES PURIFICATION PLANT, CANAL ZONE.

Excellent results were obtained in the first year's operation of the Miraflores purification plant of the Panama Canal Zone. The filters of this plant are equipped with concrete false bottoms and are among the first of this type to be placed in service in a tropical country. The plant began operation on March 14, 1915. The results are described by Mr. George C. Bunker, Physiologist to the Panama Canal, in charge of purification of water supplies in the Canal Zone, in the last annual report (for fiscal year ending June 30, 1916) of the Governor of the Panama Canal, from which the following notes are taken:

The Miraflores purification plant supplies filtered and sterilized water to Paraiso, Pedro Miguel, Corozal, Balboa, Balboa Heights, Ancon and Fort Grant, in the Canal Zone, and the city of Panama, with a combined population of about 75,000. The source of the raw water is the Chagres River arm of Gatun Lake at Gamboa. This river is approximately 65 miles long, with a drainage basin of 559 square miles. Gatun Lake backs up the river for about 10 miles, so that a mixture of the two waters forms the raw water supply of the filter plant. The plant comprises the following units: Aeration basin, sedimentation basin, rapid sand filters, clear water basin and sterilization chamber.

Aeration Basin.—This basin, measuring 86 by 130 ft., is equipped with 105 nozzles, which are arranged in 7 batteries of 15 each. The nozzles are so adjusted that, under ordinary operating conditions, the raw water is discharged at an angle of 20° in a thin sheet, which breaks up into coarse or fine drops, depending upon the height to which the water is thrown, which averages about 15 ft. The percentage reductions in free carbonic acid effected by the aeration, based on the difference between the means, in the order of the months beginning July, 1915, and ending June, 1916, run as follows: 55, 61, 61, 45, 57, 54, 52, 54, 47, 53, 57 and 59.

The addition of free carbonic acid due to the use of alum, varying from 119 to 249 lb. per million gallons, increased the final content of the filtered water to 2.7 to 13.5 parts per million, with a general average of about 6 parts.

The following table, prepared from 37 determinations of dissolved oxygen, shows the increase effected by the aeration:

	Parts per million.		Per cent of saturation.	
	Raw.	Aerated.	Raw.	Aerated.
Median	5.13	7.50	62.5	92.0
Mean	5.23	7.64	61.4	94.3
Maximum	7.30	8.03	77.0	98.0
Minimum	3.20	6.66	40.7	81.0

The varying intensities of the odors in the raw water have always been reduced by the aeration, so that the filtered water has never been characterized by an odor of an intensity greater than 1, using Whipple's scale as a basis.

The aerated water flows over three weirs into three concrete mixing chambers located in the basement of the head house. Each chamber, 37 ft. long, 15 ft. wide and 8 ft. deep, is divided transversely into eight compartments by 6-in. walls, which form alternate submerged and overfall weirs. The alum solution is added to the aerated water as it enters the first compartments of the mixing chambers by means of a specially designed orifice box.

Sedimentation Basins.—After passing through the mixing chambers the raw water discharges into three cross-connected parallel concrete sedimentation basins. The length of each basin is 300 ft., the combined width of the three is 125 ft., and the depth at the floor valleys is 17.75 ft. and that at the summits 16.5 ft. At the present time an average sedimentation period of 11 hours is obtained.

Each basin is divided into three compartments by two pressure baffle walls, which are provided with five rectangular openings, 1.5 ft. wide by 6 ft. long, placed 3.4 ft. below the water level. Extending across these baffle walls in front of the openings there are concrete skimming troughs which reach to within a foot of the normal water level. Between the pressure walls there are two light baffle walls which contain four openings 6 ft. wide, extending from within 2.5 ft. of the top to 3 ft. from the bottom of the basin. All of the valves on the underdrainage system of the basins are hydraulically operated gate valves, controlled from an operating table located in the head house.

By means of weirs in the two divisional walls at the inlet end the three basins may be operated as one large basin, water passing from one to the other. Each basin is also equipped with gates at the outlet end, so that any one may be thrown out of service for cleaning.

Only 0.66 per cent of the water treated with alum was wasted in cleaning the basin at this plant, as compared with 5.88 and 6.54 at the Mount Hope and Agua Clara plants. A similar multiplication of bacteria does not interfere with the operation of the plant.

At the filter building end of the sedimentation basin the settled water enters a receiving box, from which it passes upon the filters through two 30-in. cast iron pipes.

Rapid Sand Filters.—There are 14 rapid sand gravity filters, constructed of reinforced concrete, measuring 19.75 by 21.5 ft., and 11 ft. deep to the floor, in which the underdrainage system is placed. They are arranged in two rows of 7 units each, with the operating floor and pipe gallery between. Each unit has a sand area of 425 sq. ft., or 0.00975 of an acre, making a total of 5,950 sq. ft. If operated at a rate of 125,000,000 gal. per acre per day each unit will deliver 1,220,000 gal. per 24 hours.

In place of the usual ridge block and pipe systems of underdrainage there is a reinforced concrete false bottom, 12 in. thick, which forms the top of a pressure chamber 2 ft. deep. In the false bottom there are placed 1,677 vertical ⅜ in. brass feed pipes, spaced 6 in. center to center. The ends of the pipes projecting above the false bottom are bent 180°, so that the wash water instead of discharging upward is deflected directly upon the floor or gravel. On the ends of these pipes are screwed brass strainers, leaving a space of about 1¼ in. between the latter and the floor, or top of the false bottom. The strainer is a slightly buckled circular plate ⅞ in. in diameter, pierced with 25 1/16 in. holes, and swedged into a hexagonal base, ending in a ⅜ in. threaded sleeve for screwing over the ⅜ in. brass feed from the pressure chamber.

In each filter there are 24 in. of Chagres River gravel arranged in three layers, as follows:

Layer.	Thickness. Inches.	
Bottom	8	Passed by 1¾-in square mesh Retained on 1-in square mesh.
Middle	12	Passed by 1-in. square mesh Retained on 7/16-in square mesh
Top	4	Between 7/16 and 3/16 in. in diameter

Thirty inches of Chame Beach sand, with an average effective size and uniformity coefficient of 0.41 and 1.7, respectively, complete the filtering material.

An independent air system is placed between the small and medium grades of gravel. The air wash has been used only a comparatively few times during the year in order to assist in the breaking up of hard spots and removing mud patches.

The pressure chambers were built to withstand a maximum pressure of 28 lb. per suare inch. When a filter is washed at a rate of 6,400 gal. per minute, or 15 gal. per square foot of sand surface, equivalent to a 24-in. rise of wash water per minute, a pressure of about 12 lb. per square inch is developed on the false bottom. Under these conditions an excellent distribution of wash water results and the sand bed is raised 8¼ in. above its normal elevation, or to within 12½ in. of the weirs of the wash-water troughs.

The strainers were not placed on the feed pipes in three of the filters. When washed at the same rate as the filters equipped with strainers a pressure of 6 lb. per square inch is developed on the false bottom. The distribution of wash water is equally as good, and the sand is floated to the same height above its normal level. At the end of the year pressure chambers of filters equipped with and without strainers were examined, and it was found that no sand had worked down through the feed pipes in either case. From the experience gained during the year with filters of this type it is considered that strainers are unnecessary.

In April, 1915, the distance from the tops of the troughs to the sand ranged from 18.6 to 21.85 in.; in June, 1916, the distance ranged from 18.7 to 22.67 in. The average loss of sand during this period was 0.82 in., representing a total loss of 2.42 cu. ft. for the 14 filters. This sand has been washed over the edges of the troughs. Neither sand nor gravel has been removed from any of the filters during the year, and no repairs of any nature have been made to the filter bottoms.

The wash water is effectively removed by one central and six lateral concrete troughs. Weirs are cut in the troughs so that the maximum travel of suspended particles is limited to 2.5 ft. When washing at the rate mentioned above the depth of water over the weirs is 1¾ in., and there is sufficient current at the filter wall ends of the lateral troughs to prevent the settling out of suspended particles.

Each filter is operated by hydraulic valves controlled from a slate operating table, each of which, in addition to the usual equipment, is provided with small 10-watt green and red lamps, so connected that the former burns when the filter is in operation, and the latter starts to burn when the loss of head reaches a fixed point.

The discharge of filtered water from each filter is regulated by a controller which consists of a simple round open-top concrete box, approximately 2.5 ft. in diameter, and 3.5 ft. deep, cast on the floor of the pipe gallery; a circular bronze orifice cast in the floor and opening into the clear-water basin; a copper float 2.25 ft. in diameter carrying a stem which will operate a small vertical piston valve, and a 10-in. hydraulic valve placed on the effluent line leading into the controller box. By adjusting this float the discharge from each unit may be varied from 1,120,000 to 1,317,000 gal. per 24 hours, at the respective rates of 115,000,000 to 135,000,000 gal. per acre per day.

The following table summarizes the data relating to the filters:

Number of units	14
Sand area per unit, sq. ft.	425
Dimensions of unit:	
Length in feet	21.5
Width in feet	19.75
Depth in feet to false bottom	11
Depth in feet to true bottom	14
Wash-water troughs:	
Type	(1)
Number	(2)
Thickness of concrete, inches	2.5
Dimensions—	
Main trough, feet	21.5 by 2.42
Lateral troughs, feet	8.66 by 1.66
Per cent of sand area covered by horizontal area of troughs	32.8
Average distance above sand, inches	21
Washing of filters:	
Type	(3)
Vertical rise of water per minute—	
Figured on area below troughs, inches	24
Figured on area at plane of troughs, inches	35.8
Gallons of water per minute	6,400
Gallons of water per square foot of sand surface	15
Sand bed lifted above normal, inches	8.25
Loss of head through filter—	
Equipped with strainers, feet	27.6
Without strainers, feet	13.8
Maximum travel of suspended particles, feet	2.5
Depth of water over edges of troughs, inches	1.75
Filter bottom:	
Type	(4)
Material	(5)
Thickness, feet	1
Feed pipes, brass—	
Diameter, inches	0.364
Position	(6)
Spaced centers, inches	6
Total number per filter	1,677
Strainers—	
Type	(7)
Position	(8)
Number and size of holes	25; 1/16-inch
Relation between area of holes in strainers and the sand surface of one filter	(9) 1 to 475
Relation between area of holes in feed pipes and the sand surface in one filter	(10) 1 to 350

[1] Reinforced concrete.
[2] One main and six laterals.
[3] High velocity water wash, separate air system.
[4] False bottom.
[5] Reinforced concrete.
[6] Vertical, with ends projecting above false bottom 180°.
[7] Hexagonal base and circular plate, ⅞ inch diameter.
[8] Screwed on feed pipes, pointing downward.
[9] Or 0.21 per cent.
[10] Or 0.28 per cent.

Filtering material:	
Sand—	
Source	(11)
Depth, inches	30
Effective size	0.41
Uniformity coefficient	1.70
Gravel—	
Bottom layer (thickness, 8 inches), size in inches	1¼ to 1
Middle layer (thickness, 12 inches), size in inches	1 to 7/16
Top layer (thickness, 4 inches), size in inches	7/16 to 3/16
Operation:	
Loss of head—	
Average initial, feet	1
Average final, feet	11.5
Normal depth of water over sand, feet	5.25

Clear Water Basin.—This basin is located under the filter building, and has a capacity of 900,000 gal.

Sterilization Chamber.—From the clear water basin the filtered water flows through a 30-in. cast iron main and Venturi meter into the sterilization or injection chamber, in which is installed the orifice tanks for controlling the application of hypochlorite of lime. "The injection chamber is, in a general way, a concrete pressure box approximately 24.5 ft. by 17 ft. by 6 ft., inside depth, divided longitudinally into two main divisions. The water may be allowed to pass through both divisions simultaneously, or through one, while the other is closed down for cleaning or repairs. Each division is divided into compartments having curved and flat-faced concrete baffles placed in them, of such design and arranged in such a manner as may be expected to give the utmost agitation and mixing to the water as it passes through. Upon entering the first compartment of each division the water will pass through two vertical slots about 5.5 ft. in length by 6 in. in width, in front of which, splitting the flow, will be placed two perforated bronze solution pipes which will enter the top of the chamber through a regular stuffing box."

As the chamber is under an average pressure of 17 lb. per square inch, it is necessary to pump the solution into the water by duplicate motor driven centrifugal pumps. Twenty days after the plant was placed in operation it was found that the accumulation of calcium carbonate on the interior of one of the pumps and its discharge line was of such thickness as to prevent the delivery of the normal volume of hypochlorite solution. Throughout the year it has been necessary to clean the pumps and discharge lines about every 10 days. The duplicate equipment allowed this to be done without any interruption to the application of the hypochlorite.

On account of this trouble and the high cost of hypochlorite, one of Wallace & Tiernan Co.'s automatic chlorinators was purchased. Its installation was under way at the end of the fiscal year.

The following table contains the yearly means and medians of the numbers of bacteria in the raw and sterilized water as determined on nutrient and lactose agar incubated at 37.5° for 24 hours.

	Nutrient agar.		Lactose agar.	
Source.	Yearly mean, per cc.	Yearly median, per cc.	Yearly mean, per cc.	Yearly median, per cc.
Raw water	266	192	96	55
Water delivered to mains	1.5	0	1.0	0
Water from taps on distribution system	32.9	4	5.8	1

The monthly averages of numbers of B. Coli in the raw water varied from 186 to 2,715 per liter, with a yearly average of 1,225; in the sterilized water distributed to the mains, from 0 to 16.7 per liter, with a yearly average of 4.4, and in 7 out of 12 months B. Coli were not found in 1 and 10 c.c. amounts of water; in the water collected from the distribution system from 0 to 41.9 per liter, with a yearly average of 12. Bacteria of a general group of lactose fermenting anaerobes have been isolated from presumptive tests made on samples of sterilized water collected both at the plant and from the distribution system in Panama and Ancon.

Physical and Chemical Data.—The odor of the raw water varied from 1 e to 4 e, or 1 v to 3 v, and that of the filtered water from 0 to 1 v. The turbidity of the raw water varied from 1 to 102, all of which was removed. The color of the raw water ranged from 10 to 153, and that of the filtered water from 0 to 10. The alkalinity of the raw water varied from 39.4 to 60.5, and that of the filtered water from 29 to 51.7 parts. The soap hardness of the raw water varied from 29.9 to 57 parts, and that of the filtered water from 29.6 to 49.1 parts. The oxygen consumed of the raw water varied from 0.40 to 3.20, and that of the filtered water from a trace to 2.2 parts. The free ammonia in the raw and filtered water varied from 0 to 0.046. The albuminoid ammonia in the raw water varied from 0 to 0.098, and that in the filtered water from 0 to 0.060 parts. The nitrates in the raw water varied from 0 to 0.12, and in the filtered water from 0 to 0.10 parts. The chlorine in the raw water varied from 4.8 to 10.3 parts. The iron in the raw water varied from 0 to 3.4, and in the filtered water from 0 to 0.08 parts. The total solids in the raw water varied frm 95 to 182, and in the filtered water from 93 to 136 parts.

Operative Data.—The monthly volumes of raw water varied from 226,376,000 to 272,178,000 gal., with a yearly average of 248,963,000 gal. The monthly volumes of water delivered to the mains varied from 217,997,000 to 256,297,000 gal., with a yearly average of 243,081,000 gal. The monthly volumes of wash water varied from 2,992,000 to 6,891,000 gal., with an average of 5,126,000 gal.

The "gallons per filter hour" varied from 51,400 to 54,000, with a yearly average of 53,000. The "million gallons per acre per day" varied from 126,200,000 to 132,900,000, with a yearly average of 130,300,000. The average filter runs per month varied from 21.7 to 50.6 hours, with a yearly average of 31.3 hours. The maximum filter run per month varied from 39.7 in February, 1916, to 95.9 hours in November, 1915. The minimum filter run per month varied from 2.0 hours in July, 1915, to 31.5 in May, 1916.

The "number of filters washed" varied from 86 in November, 1915, to 185 in February, 1916, with a yearly average of 149. The "per cent of wash water" varied from 1.26 in November, 1915, to 2.67 in March, 1916, with a yearly average of 2.07.

The pounds of alum consumed per month varied from 30,755 in March, 1916, to 59,240 in November, 1915, with a yearly average of 43,502, and a total of 522,024 lb. The pounds per million gallons varied from 119 to 249 for the above months, with a yearly average of 175.

The pounds of hypochlorite consumed per month varied from 3,589 to 4,975, with a yearly average of 4,428 lb. Figuring on a basis of 35 per cent available chlorine, the pounds applied per million gallons varied from 13.2 to 19.5, with a yearly average of 16.1. The parts per million of available chlorine varied from 0.55 to 0.82, with a yearly average of 0.68.

WEEKLY REPORTS AS AN AID TO WATER PURIFICATION PLANT INSPECTION.

The State Board of Health of Indiana requires that all water purification plants shall make weekly reports of operation to the Water Department of the Board. The advantages of this procedure are outlined by Mr. J. C. Diggs, Sanitary Engineer, State Board of Health, in a paper presented Feb. 14 before the Indiana Water Supply Association. Extracts from the paper follow:

These weekly reports, which come to the department on a printed form supplied to each purification plant, furnish data which includes such items as total and daily pumpage, rate of chemical feed and total chemical added during the week, and bacterial condition of the purified water. Although it was well known that the purification plants of the state are by no means uniform in the quality of raw water which they are required to purify or methods and degree of purification, to simplify the work a uniform blank is supplied to all. In many cases this work necessitated only the filling in of data which already were kept in the plant. In other cases, however, plants were found which kept absolutely no record of the amount of water pumped or amount of chemicals used, and, in fact, many plants have no definite means of measuring the volume of water which passes through their pumps other than the rating of the pumps as supplied by the pump manufacturers.

In fact, very few small water plants keep anything like

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[11] Chame beach

an accurate record of pumpage. Many of the larger plants do not. Often it is impossible to get even an approximation of the quantity of water pumped, for generally the only records are from the pump revolution counters, without any allowance for slippage. The installation of meters in all plants is strongly advocated. Without meters it is practically impossible to apply an accurate feed of chemicals. The reports from one Indiana plant indicate that the pumpage for each and every day since Oct. 1 has been exactly 1,000,000 gal. In spite of the fact that this plant furnishes considerable water to industrial concerns of the city, no decreased pumpage is shown for Sunday or other days when the manufacturing concerns are not in operation. It is difficult to believe that the pumpage of this water plant continues for a period of several months with such unchanging regularity.

The responsibility of guarding the water supply has been shifted from the individual to the city authorities or officials of the corporation furnishing the supply. With the installation of the filter plant or other chemical treatment process a supply drawn from a turbid and sewage-contaminated stream can easily be made to have the physical appearance of purity, even though it may yet contain the organisms of the most virulent character. The layman who drinks the supply knows not whether he is drinking a potable water or one from which suspended clay and sand alone have been removed. Some plants and some local boards of health have laboratories which serve the purpose of checking up and determining the quality of the supply furnished the people. Other plants have no such laboratories, but depend upon a satisfactory removal of the organisms with the removal of clay particles whose presence is indicated by the physical appearance.

The writer is of the opinion that no purification plant should be permitted to operate until it is equipped with a laboratory and a bacteriologist who will make daily examinations to determine if the processes of purification have been efficient. Any contaminated water supply is varying in degree of contamination, and a treatment one day will not be sufficient for conditions which exist another day. Many of the Indiana plants are fortunately equipped with control laboratories, many of which are doing excellent work in maintaining a high standard of output. In a few instances, however, the department is convinced from the weekly reports that the bacterial work is done in a very haphazard manner, and in some cases the very uniformly good results of some plants show such surprisingly perfect results that the department is inclined to doubt their correctness.

Great variation in sterilization treatment in plants exists. Chlorine treatment of waters varies from 1½ to 6 lb. per million and the use of hypochlorite ranges from a rate of 6 lb. per million gallons to 25 or 30 lb. per million gallons. It is greatly to be feared that some operators neglect proper operation of their filters, depending upon the use of a disinfecting agent to remove harmful bacteria.

Records assist in efficiency in operation and add to the quality of the output. While the State Board of Health strongly advocates any plan which will bring about more economical operation of a water plant, it is far more vitally interested in seeing that water purification plants produce a potable water supply.

A NEW SERVICE BOX.

A new service box, embodying a number of interesting features, has recently been placed in the market by the H. W. Clark Co., Mattoon, Ill. This C. M. B. service box has a heavy cast iron base and a sliding extension feature, which allows raising and lowering through action of frost without disturbing the base setting. This insures proper height at all times, and surface load and stresses are not communicated to the service cock or pipe. The box has a flanged top, affording a good support at surface of ground. With this box the service cock is always in the center, and is held securely in position by interior box construction. No rigid connection is required between the box and the service cock.

A NEW FRAME FOR BASEMENT METER INSTALLATIONS.

A new design of meter holding frame has recently been placed in production by the Ford Meter Box Co., Wabash, Ind. This is claimed to be a most efficient device for installing water meters in vertical pipes in basements. The frame is easy to install, is stated to be cheaper than ordinary fittings (time included and offers practically no resistance to flow of water. Each one is tested to 200 lb. pressure. Regular meter connections are not required. The frame will take any standard ⅝-in. meter or ⅝-in. meter with ¾-in. spuds. Larger sizes are not yet in production. The device, which is shown in the accompanying illustration, is known as the Ford "Rams-horn" Meter Holding Yoke.

"Rams-Horn" Meter Holding Yoke.

MACHINE CAULKING OF PIPE JOINTS.

One of the many uses to which portable air compressors can be put is that of operating pneumatic tools for caulking pipe joints. In 1915 the Burro Mountain Copper Co., Tyrone, N. M., employed a Sullivan 6x6 WC-3 belt-driven air compressor mounted on skids and operated by an 8-hp. gasoline engine for this kind of work. The tools used consisted of two Sullivan "DB-13" hitch cutting tools, with special caulking tools made up by the user.

The compressor and engine were set at one point along the line of work until the air line was extended a distance of 500 ft., at which time the outfit was moved so as to catch up with the work. The air line consisted of ¾-in. pipe and 80 lb. pressure was maintained. The 12-in. pipe was laid in lengths of 10 to 15 ft. and about 400 ft. per day were laid and caulked. Each drill caulked from 15 to 20 of the 12-in. joints per day. Oakum and soft lead were used for caulking, due to the fact that the spaces between the joints were too small for lead wool. The foreman stated that 50 per cent more of pipe could have been laid per day if the trench ahead of them had been dug fast enough to permit that amount of pipe being laid.

PERSONALS.

C. E. Johnston, heretofore Chief Engineer of Kansas City Southern Ry., has been promoted to the position of General Manager.

Hobart L. Cory and Francis W. Du Bois have organized the firm of Cory & Du Bois, Civil Engineers, Baker, Mont., and will specialize in water supply, sewerage, sewage disposal and other municipal work.

John C. Payne, Trenton, N. J., has been appointed Chief Engineer of the New Jersey State Board of Commerce and Navigation, succeeding B. F. Cresson, Jr., who resigned to engage in a consulting practice.

Clark R. Mandigo has resigned as Assistant Engineer of Portland Cement Association to accept the position of Consulting Engineer for the Western Paving Brick Manufacturers' Association, Dwight Bldg., Kansas City, Mo.

Gustavus W. Thompson and Walter D. Binger have organized a corporation under the firm name of Thompson & Binger, Inc., and will engage in the design and construction of plain and reinforced concrete structures of all types. Mr. Thompson is President, Mr. Binger, Vice-President and Treasurer; Raoul C. Gautier, Chief Engineer, and Oscar Matthys, Superintendent of Construction. Offices have been opened at 280 Madison Ave., New York, 516 Gurney Bldg., Syracuse, N. Y., and at Binghamton, N. Y.

INDUSTRIAL NOTES.

The Pulsometer Steam Pump Co., Irvington, N. J., has moved its Chicago offices from the Lytton Bldg. to the Old Colony Bldg., 415 South Dearborn St.

Wallace & Tiernan Co., Inc., 137 Center St., New York City, manufacturers of chlorine control apparatus and scientific engineering specialties, announce the following changes in their organization, and additions to their technical staff. On March 15th, a Chicago office will be opened at Peoples Gas Bldg., Michigan Blvd. & Adams St., Chicago, Ill., Room 550, with Mr. C. A. Jennings in charge. Mr. Jennings is well known to water works men through his connection with the Bubbly Creek Filters of the Union Stock Yards, and his research work in the field of water purification, particularly along the lines of chlorination. Mr. H. K. Davies will be transferred from the New York office to Chicago as assistant engineer to Mr. Jennings. Mr. J. C. Kaelber has been appointed to the technical staff as Assistant Engineer. Mr. Kaelber is a graduate of the University of Rochester and was formerly connected with the Western Electric Company. Mr. R. V. Donnelly has also been appointed to the technical staff as assistant sanitary engineer. Mr. Donnelly is a graduate of Columbia University and was formerly connected with the New York Continental Jewell Filtration Co.

Dirt Mover and Pit Owner Issue
of
Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

First Wednesday Each Month............Roads and Streets......$1 Yearly
Second Wednesday Each Month, Waterworks and Hydraulics.......$1 Yearly
Third Wednesday Each Month....Dirt Mover and Pit Owner......$1 Yearly
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Fifth Wednesday.......Planning and Management Quarterly...25 cts. Yearly
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Contract News Appears in All Issues

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THE COMMON MISTAKE OF NOT MEMORIZING USABLE FACTS AND DETAILS.

Our engineering colleges are responsible, we believe, for the prevalent opinion among engineers that an engineer should not "burden his mind" with many facts—should not memorize much more than is absolutely essential to the application of "general principles." This opinion is one to which is traceable a vast deal of incompetence among engineers, old as well as young.

In the course of his series of articles on "Logic for Engineers," the editor purposes showing that there is an undue worship among scientific men of all "general principles," or "natural laws," as means of securing greater economic efficiency. It will be proved that by all odds the major part of most men's effective thinking consists in a sort of reasoning that has fallen into ill repute among logicians and educators, namely, "reasoning from particulars to particulars." Ever since the time of Aristotle there has been an unduely exalted respect for the syllogistic form of reasoning—that is "from generals to particulars"—which even Francis Bacon was unable to shake. Indeed, Bacon promoted an even greater respect for "generalizations," by furnishing a system of inducing natural laws from a mass of facts.

While it is not our purpose to anticipate the later discussion of the limitations of the process of reasoning from "general laws" to particular applications, we do wish to raise at this time a vigorous protest against the quite common practice of reading engineering and scientific literature without attempting to memorize much more than a few very general conclusions.

Is it not significant of a false theory of education that the "uneducated man" so often excells the "educated man" in business life? Many of us have attributed this phenomenon entirely to differences in natural ability. But let us not be too sure of the correctness of such a simple solution of the problem. Successful business men of all classes are constantly complaining that "educated young men" are "impractical," and that it takes years of pounding to reshape them into the desired habits of precision, attention to details, and **the habit of remembering exactly what they are told.**

Of course no one will deny for a moment that a good memory is a great asset to any man, but our teachers, especially in recent years, have been constantly lecturing against what they call "mere parroting," until it is small wonder that most students have come to have no respect for any kind of "parroting." Why, it is even fashionable now to discourage a boy from memorizing the multiplication table! Yet it is well that we have come to such an absurd extreme, if only to make more evident the ridiculousness of prevalent theories about not "burdening the memory with details."

Coming now to a few every-day questions relating to construction: Which sort of a man is quickest to meet a construction emergency, an educated engineer or an uneducated foreman? Have you ever seen the falsework of bridge threatened with a washout from a jam of logs above? If so, who has known just what to do before the bridge went out? The editor has been the engineer as well as the contractor in such an emergency, and has had to confess that without the advice of his foreman the bridge would have been lost. That same foreman had, "under his lid," a ready way of meeting every emergency. After the foreman had shown how to accomplish a given purpose, it was always easy to see what general laws of mechanics he was applying, and it was often possible then to improve on his method. But prior to being shown what particular application of a general mechanical principle is best under a given condition, there is probably not one engineer in a thousand who can ordinarily solve a practical construction problem as well as an uneducated but experienced foreman. The editor does not use himself as the sole standard by which to judge "foremen vs. engineers," for he has seen the helplessness of scores of other engineers under just such conditions as above related.

The editor, largely as a result of becoming a contractor, came to realize that it is even more important to memorize practical solutions of construction problems than to know the general laws of nature relating to those problems. He also saw something that many practical men lacking education do not see, namely, that a man can garner a vast harvest of the experiences of other men by reading; in short, that a man need not necessarily see a thing done to learn how to do it. Therefore he began to clip articles and keep notes of the various solutions of "practical problems" of every sort of engineering construction in the field.

The editor did not stop there, however, but he made it a practice periodically to go through his clippings and notes, refreshing his memory. In a relatively short time he thus became able to give some sort of effective answer, offhand, to any ordinary construction problem and to a great many that were not ordinary. Not in 200 years of actual construction work could the editor have secured from personal experience the experiences that are now his as a result of reading and memorizing what he has read. Consequently, times without number the editor has been able to tell contractors, by word of mouth, how to reduce costs or solve a troublesome problem. The editor is no longer a consulting engineer, so that he feels more at liberty thus to "blow his own horn," since the object of the present "heralding" the facts is merely to show a path that others may tread with greater success.

The "practical man" is the man whose mind is stored with experiences of special methods of doing things. These experiences need not be all his own. Any published experience of any other man may be counted as possessing as great value as one's personal experience, providing the published experience is fully detailed and is seen in imagination with sufficient vividness. To make a published fact vivid to you, read it with the feeling that some day you are likely to apply it. Read it in the belief that your success in life rests upon your mental preparedness. Read it with the purpose of turning it over in your mind to see whether you cannot improve upon it. When thus read, facts from other men's experience become your own. Your mind takes on not merely wisdom but alertness to apply knowledge. A mere book-worm, of course, has no chance in life to be more than an encyclopedia in pants, one not apt to be consulted because of his known lack of practice in applying his knowledge. But the practical man who "worms" into books and periodicals is no "book-worm." He is a woodpecker after the "worms."

Let us start to put an end to conventional phrases such as these: "I am too busy to read." What? Then you are too busy to succeed in a large way.

"I do not believe in studying, much less memorizing detail methods." What? Then you are more gifted naturally than Edison, for he is voracious in his appetite for details.

"There is so much printed that I can't possibly learn more than the meagerest part of it, so I don't attempt to learn anything until I must." What? Would you start your first practice on a violin the day before the concert?

Nature abhors a vacuum; so also does every business man, and his particular abhorrence is for a vacuous head wherein a brain empty of detail facts rattles around with a sound of hollow generalities.

General principles of chemistry never taught a cook how to season a sauce. There is real meaning in the term "an experienced chef," and the meaning that is there applies to you and to me. The "experienced chef" has learned the worthwhileness of studying the recipes that other cooks have found palatable, and thereto he has added his own successful experiments. To the science of cookery he has applied "art," and most of that "art" is his "inheritance" of the experience of other cooks.

So it is in every walk of life, even the most scientific. There is a definite limit to progress through the application of "general laws," whereas progress through the application of "narrow experiences" is illimitable.

"SOME CRUSHER" AND SOME LESSONS FROM ITS USE.

In our February Dirt Mover and Pit Owner Monthly issue, we described the largest rock crusher in the world, and it is "some crusher." If one tall man stood at the base of the crusher, and five other tall men pyramided on him, the top man could just peer over the top of this crusher—34 ft. high.

It is a Kennedy gyrating crusher, the outside diameter of whose hopper is 22 ft. It will receive a stone 5 ft. in diameter and reduce it to 8 in. and smaller fragments. Driven by a 300 H.P. motor, it has a capacity of 25,000 tons of limestone per day of 20 hours, or 1,250 tons per working hour!

One of the interesting features in our last month's article about this crusher is the fact that it is driven by the English system of "rope drive," one of the prime objects of which is to secure continuity of service. There are 18 Manila ropes (1¼-in.), on the driving sheaves, and even if half of these ropes were to break the crusher could continue to run.

Is there not a thought here well worth pondering by all quarry and pit owners and contractors who operate crushers, regardless of the size of the crusher? Continuous crusher service during the working day is far more important, as a rule, than the actual cost of all the repairs put together. In other words, the lost wages of men during a breakdown, to say nothing of the lost profits through reduced output, is of greater moment than the cost of repairs. Consequently even though a belt-drive might show less expense for belt renewals than a rope-drive, it would pay well to use the rope-drive to secure greater continuity of output of the crusher.

Long ago it was recognized by operators of crushing plants that it is usually cheaper to invest in large crushers capable of receiving large rocks than to space drill holes close together and subsequently block-hole or sledge the large rocks to a size that will enter the throat of a small crusher. But we have been many years in coming to a full appreciation of the economic importance of this old conclusion. Indeed, we have, even yet, only just begun to appreciate fully what can be saved through the use of very large crushers where the annual output of stone justifies the investment.

The editor recalls the first mistake that he made in buying his first crusher. It was a small jaw crusher, 9x16 in., an excellent little machine. He bought it second-hand at a "real bargain," so far as the price paid was concerned, but it was far from being a real bargain when it came to operation. The cost of sledging the limestone, even with drill-holes spaced only 6 ft. apart, was above 15 ct. per cu. yd. of crushed stone—or $9 a day on an output of 60 cu. yd.

Realizing that a mistake had been made, the editor sold the crusher for half what he had paid for it, bought one that would receive stone of twice as large dimensions, and reduced the cost of sledging to 3 ct. per cu. yd., to say nothing of cutting the cost of drilling in two through being able to space the holes 9 ft. apart instead of 6 ft. He thus learned that the problem of economic production of crushed stone is quite a complex problem. It is one in which drilling and sledging costs are dependent very largely upon the size of opening in the crusher, and it is also a problem in which continuity of operation of the crusher is of very great importance.

USE OF ELECTRIC MOTORS IN GRAVEL AND STONE PLANTS.

Our attention was recently called to a photograph of a small rock crushing plant driven by a 30-h.p. motor. The plant was turning out 6 cu. yd. per hour, and the contractors who owned it expressed satisfaction with the economy and reliability of its operation. The motor not only drove the crusher and elevator, but was used to operate a winch for hauling cars of rock up an incline.

In and near cities, electricity can usually be purchased for power at prices under 5 ct. per kilowatt-hour. As a kilowatt is one and one-third horsepower, this is equivalent to about 4 ct. per horsepower-hour. But this does not mean that a 30-h.p. motor would use $12 worth of current in a 10-hour day, even at 4 ct. a horsepower-hour; for the fact is that the full power of the motor is used only occasionally, and then for but a few moments.

We do not have the current consumption for the small plant above mentioned. The editor's experience has been that in crushing and elevating a cubic yard of stone with a small jaw crusher about 15 lb. of coal are required for limestone, and about 18 lb. for tough trap. Considering the fuel losses involved in operating a 20-h.p. boiler and engine, it is likely that a consumption of 900 lb. of coal per day of 10 hours indicates an actual 10-hour average of less than 10-h.p. and perhaps as low as 6-h.p. If, then, a 30-h.p. electric motor averages only 7½-h.p., or 75 horsepower-hours per 10-hour day, and if the price of the current is 4 ct. per horsepower-hour, the current cost is $3 a day.

Now a small crusher using 0.4 ton of coal a day at $4, requires only $1.60 for fuel; but this is only a "starter" in the expense of the steam power. There is the wage of the engineman, and the interest, repairs and depreciation of the boiler and engine, besides the cost of water, lubricating oil and other incidentals.

It will certainly pay the owners of small crushers to investigate the matter of using electric motors. The owners of large sand and gravel plants and stone plants should be even more alert in studying the possible use of electric power.

We have little doubt that one of the chief reasons why electricity is not more often used in such plants is this: The owner of the plant knows quite accurately what the total horsepower of the installation is, or should be, but he knows little or nothing as to the "load factor." This is because he has no means of arriving at the average power used except through a calculation based on the daily coal consumption, which at best is not a very satisfactory way. Many electric companies doubtless have accurate knowledge as to the quantity of current consumed by screening and crushing plants. From these companies the manufacturers of motors should gather data to show contractors and pit owners what the operating cost with electric equipment will be.

We shall endeavor to secure reliable information of this sort for publication in the near future.

A NOVEL METHOD OF BUILDING HIGH DIKES.

In building high dikes of "glacial drift" there is always risk that the water will penetrate the dike unless great pains is taken to puddle it. But puddling, or any other ordinary method of securing watertightness, is apt to be very expensive. About six years ago the editor saw an effective and relatively cheap method of building watertight dikes that is worthy of description.

The work was part of the White River power project near Seattle, Wash., and was done by Stone & Webster. Several miles of dikes, or more properly low earth dams, were built to enlarge a lake. The material was "glacial drift"—gravel, sand and clay, unevenly mixed. It was, for the most part, dug with steam shovels, hauled in dump-cars and dumped through trestles, long stretches of which were about 30 ft. high.

When such material is dumped in this manner it is quite porous. In order to consolidate it, a small wrought-iron pipe was laid along the trestle and from this pipe water was constantly played onto the new embankment to consolidate it by puddling. This alone, it was feared, would not suffice. Moreover, it was desired to build an embankment wide at the base and with gently sloping sides. In doing this the particularly novel feature of the work was this: Drag-line scrapers were used to spread the earth as fast as it was dumped through the trestle.

During the week that the editor was on the job the cost of spreading and puddling was about 6 ct. per cu. yd. Each drag-line scraper averaged about 550 cu. yd. per 10-hour day. Cable renewals cost about $3 a day, using a 1-in. cable. It was found that a 1⅛-in. cable was decidedly more economical than a 1-in. cable.

By selecting different kinds of materials with a little care, followed by some care in loading the drag-line bucket, a fairly good mixture of clay, sand and gravel was secured. Use of water freely served to produce dense embankments. And the total cost was believed to be well below that of any other method applicable in this case.

WASHING EARTH OFF SCOWS AND CARS.

What contractor has ever "hydraulicked," or washed, earth or sand off a flat car? There have been many contractors who have washed earth off scows, for it is a very economic way of moving earth from a scow that is not provided with pockets that can be dumped. For example, a barge holding 150 cu. yd. of dirt on its deck can be washed clean in less than half an hour, using a 12-in. pump mounted on a pump boat alongside the barge. This method is applicable in depositing earth around the outside of a cofferdam, or in filling a hole scoured in a river channel where a cofferdam is to be built, and it may be used under other conditions.

It often happens that dump cars are not available or that the job is not large enough to warrant their purchase. Flat cars, if properly rigged, may be cleared of loads of earth with a special plow designed for this purpose, but this can not be economically used on small jobs. Suppose, then, a relatively small amount of earth or sand is to be removed from flat cars, must the work necessarily be done by hand? We suggest that if a pump and a water supply are available, the materials may often be removed from the cars by "hydraulicking," and if there is a slight down grade a wooden chute may be used to carry the material to a considerable distance from the car.

IMPROVISING A "BULL WHEEL" FROM A MOTOR TRUCK OR TRACTION ENGINE.

One sort of "bull wheel" is like a capstan around which a few turns of a rope are taken to secure a "grip," the long part of the rope then being used for pulling or hauling purposes. It is often desirable to improvise such a "bull wheel," so it is well to remember that it can be done by jacking up one of the rear wheels of a traction engine or auto-truck, using that wheel for a "bull wheel." Of course the auto-truck or tractor must be anchored to resist the pull.

This same plan is frequently used to make a "pulley wheel" of one of the rear wheels of a truck, which can then be belted to a pump, a concrete mixer or what not.

A contractor who has his wits about him can frequently avoid a complete shut down of a plant by adopting expedients such as these. Incidentally, let us add, if all contractors fully realized how many such "tricks of the trade" are published annually, there would be few who would not make it part of every month's work to look carefully through Engineering and Contracting. One should not wait till he is in trouble before seeking "a way out," but by storing his memory with usable hints should be instantly ready with "a way out" of every ordinary difficulty.

This matter of reading for the purpose of memorizing good ideas is one that relatively few men do systematically. Engineers are particularly lax in this respect, for most engineers are taught at college that the "mind should not be burdened with details," but merely trained how to think and to know "general principles." Bunk and bosh! Was there ever a successful business man whose mind was not literally crammed full of details that either had been or were likely to be applicable in his business? Let us get away from the theory that old "general principles" commands the whole army of success.

HOW TO SUBSTITUTE AN ELECTRIC MOTOR FOR AN ENGINE ON A MIXER.

Elsewhere we have commented on the use of electric motors for driving rock crushers. There are not a few concrete mixers equipped with electric motors, but not every contractor realizes how simple a matter it is to change a steam or gasoline driven mixer to a motor driven mixer. Belt the motor to the engine fly-wheel and disconnect the engine from the shaft, leaving the engine in place for future use. At a cost of a very few dollars such a change can be made, the boiler being stored until again needed. Although the cost of the electric current may be twice the cost of the coal, the saving in an engineman's wages will far more than offset this difference.

Ditching with Dynamite.—Dynamite was used in blasting open drainage ditches at the experiment station farm of the Montana Agricultural College at Bozeman, Mont. The soil where the ditching was done is very gravelly and contains many large rocks, making digging difficult and expensive.

Two sticks of 60 per cent Hercules dynamite were placed in holes 22 in. apart, this distance being determined by experimenting to be the most desirable for the soil conditions. About 25 holes were usually fired at one shot, the middle hole being used for the primer. A length of 647 ft. was blasted at a cost for labor of $51.25, or $1.31 per rod. The expense of cleaning out the ditch after blasting was 27 ct. per rod, which is included in the above cost. Dynamite, caps and fuse for the job cost $1.05 per rod (dynamite at 22 ct. per pound). The following is a comparison of three lengths of ditch constructed in 1915:

Kind of work.	Length of ditch. Rods.	Total cost per rod.
Hand-dug ditch	14.0	$3.35
First length of blasted ditch	17.0	3.10
Second length of blasted ditch	39.2	2.36

Overtime Payments for Steam Shovel and Dredge Men.—The U. S. Reclamation Service has adopted the following rule to form the basis for overtime payments to steam shovel and dredge men: Time and one-half for all overtime, except when moving or digging with machine on Sundays or holidays, which shall be paid for at the rate of double time; the following holidays to be observed: New Year's Day, Memorial Day, Fourth of July, Labor Day, Thanksgiving Day and Christmas. The rule applies to engineers, firemen and cranemen employed on steam shovels and hydraulic dredges, and in order that payments may be made in accordance therewith this rule is incorporated in the contracts for employment.

CONSTRUCTION FEATURES AND METHODS IN THE LITTLE RIVER DRAINAGE DISTRICT.

Contributed by B. F. Burns.

The lower works of the Little River Drainage District involve the construction of 624 miles of drainage ditches varying from 4 ft. to 123 ft. in base width and from 8 to 11 ft. in depth. Prior to letting the work, it was necessary to assemble into contracts ditches or portions of the same as were of a size suitable for the proper construction unit, and as would be readily accessible, and would not involve a greater yardage than could be handled by the required dredge during the period of the contract. The work was assembled into 24 dipper dredge contracts. For the execution of these contracts, dredges ranging from 1 yd. capacity with 40-ft boom to 4½-yd. capacity, 90-ft. boom, with hulls proportionate in size, are required.

The first consideration of the contractor after the award, was the clearing of right of way. To conform with specifications it was necessary to cut the stumps on the berms down to 24 in. above the ground and to clear all timber, brush and debris from the channel area and berms and a sufficient distance on either side of the berms to insure the timber and brush, removed from the areas mentioned, being completely covered by spoil. The timber on the remaining right of way, or so much of it as necessary to cut, had to be felled parallel to the ditch lines. Openings in the spoil banks were required at 500-ft. intervals alternately on either side of the ditch, at all natural depressions and water courses, which were described in orders given by the engineer or staked by him, so that they might be kept free from brush and debris.

In clearing through a lowland district, it was not only desirable but necessary to complete all of the clearing possible during the summer months of the dry periods of the year, as, during the fall, winter and spring, there was so much water present that it was impossible to properly carry on clearing operations. The logs from the trees felled on the right of way had to be snaked off the area between the brush lines by teams or oxen, where skidders are not used. During the wet months it was impossible to use animals for that purpose, as they could not secure a footing. Sometimes there was a sufficient stage of water to enable the contractor to float the logs off the right of way and there dispose of them.

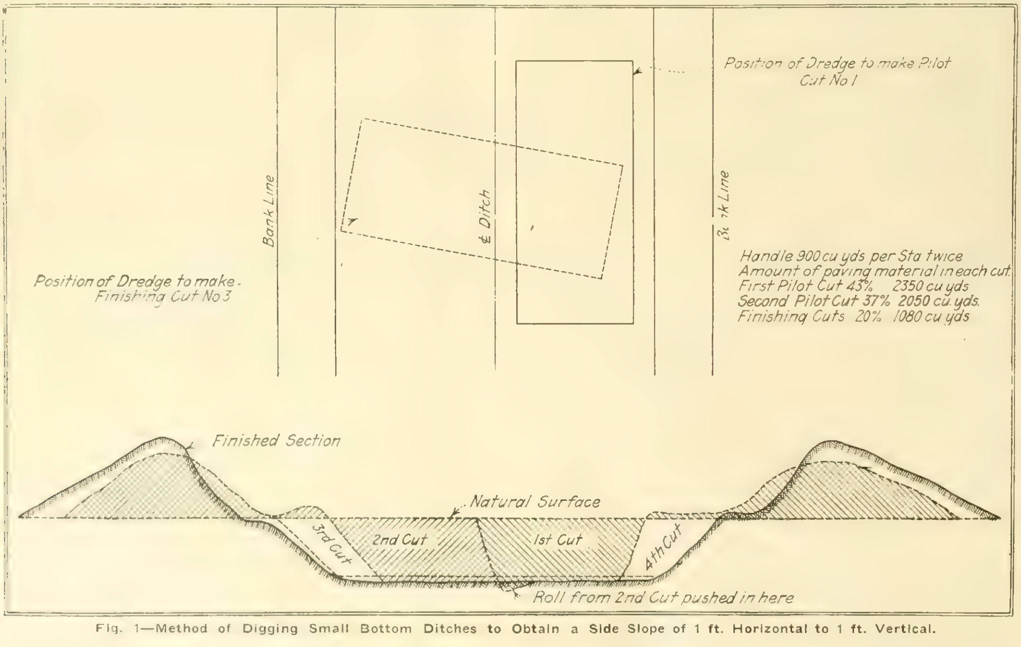

Position of Dredge to make Pilot Cut No 1
Bank Line
℄ Ditch
Bank Line
Position of Dredge to make Finishing Cut No 3
Handle 900 cu yds per Sta twice
Amount of paving material in each cut
First Pilot Cut 43% 2350 cu yds
Second Pilot Cut 37% 2050 cu. yds.
Finishing Cuts 20% 1080 cu yds
Finished Section
Natural Surface
3rd Cut
2nd Cut
1st Cut
4th Cut
Roll from 2nd Cut pushed in here

Fig. 1—Method of Digging Small Bottom Ditches to Obtain a Side Slope of 1 ft. Horizontal to 1 ft. Vertical.

Clearing of the rights of way of the largest ditches has been successfully handled by mounting a skidder on a barge and using it to snake the logs off where the overflow conditions were such as to make other operations impossible.

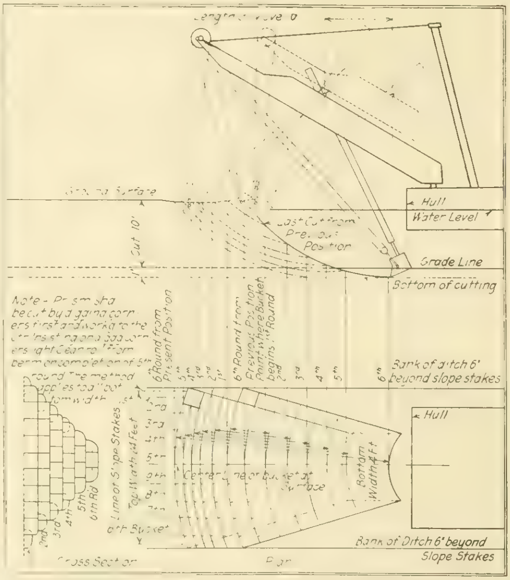

Hull
Water Level
Cut 10'
Grade Line
Bottom of cutting
Bank of ditch 6' beyond slope stakes
6" Round from Present Position
6" Round from Previous Position Point where Bucket begins 1st Round
2nd
3rd
4th
5th
6th
1st
Hull
Line of Slope Stakes
Top Width in Feet
Bottom Width 4 Ft
Center Line of Bucket at Surface
5th
6th Rd
Bank of Ditch 6' beyond Slope Stakes

Fig. 2—Method of Digging Large Bottom Ditches.

Where conditions have been such that snaking of the right of way ahead of the excavation was not possible, the usual procedure is to cut the logs into 8 or 12-ft. lengths and remove them with the dredge. One of the illustrations shows a right of way where this condition existed. This method of clearing creates a considerable hardship for the contractor, as during the period he is removing the logs with his dredge its earning capacity is practically nothing; whereas, if the right of way had been properly cleared, its operation would have been a gain instead of a loss. The conditions in which the work is left, where the right of way has not been properly cleared, are such that considerable cleaning up is required and the removal of protruding logs and debris from the inner faces of the spoil banks is necessary to make a good, clean job.

It is possible with the largest dredges to excavate the stumps within the ditch lines without first splitting them with dynamite, but with most of the dredges it is found necessary to split the stumps before they can be removed without too great a strain on the machines.

The specifications provide for the construction of ditches having side slopes of 1 ft. horizontal to 1 ft. vertical and, at the letting of the work, it was distinctly understood that this requirement would be insisted upon. The usual practice in this section, at least, had been to construct ditches with vertical sides or what is termed a "U"-shaped section. Ditches dug in that manner do not stand up. The sides slough after the ditch has been watered and unwatered a few times and the result is that the flow capacity is materially lessened and a re-dredging of the ditch is necessary after a very few years to provide adequate drainage.

Upper Right View—Showing Logs on Right of Way That Must be Handled by the Dredge. Upper Left View—Handling Logs With Dredge. The Result of Not Snaking Right of Way Ahead of Excavation. Lower Left View—Small Pilot Cuts Along Inner Berm Lnes for 123 Ft. Base Ditch. Lower Right View—Ditch With 123 Ft. Base as it Looks From Boom of Dredge.

The specifications of the Little River District were written with the idea of permanency in mind and for the purpose of securing a construction that would require a minimum expenditure for maintenance. Most contractors and even some of the engineers for the dredge manufacturers were skeptical, believing that it was not possible to dig a 1-on-1 slope with a dipper dredge, or at least that it was not within the range of the machines as constructed. However, the first dredge installed on the work found no difficulty in meeting this requirement of the specifications and, the possibility once demonstrated, the excuse that it could not be done was eliminated. As a further aid, a method of digging that would get the desired results was presented. This method is illustrated by Fig. 1, but a brief description may be of interest.

Each round is begun at the slope line, making the first cut light, and continued towards the center. When the round is half dug out, the dipper is swung to the opposite side and the remainder of the round dug out. This procedure is continued throughout the reach and then repeated after the dredge moves ahead. The illustration shows the method as applied to a ditch having a 24-ft. top, but it is not limited to that and can be used wherever the entire prism of the ditch can be taken out at one cutting.

In the construction of the large ditches with base widths from 80 to 123 ft., the possible movement of the spoil banks is a consideration. What a mass of earth excavated from ditches having such large prism areas will do, if thoroughly saturated, is problematical. To protect against this it is necessary to remove part of the excavation, deposit it along the outer berm lines and allow it to remain a sufficient time to become stable before taking out the remaining excavation. Several methods of handling the excavation of these large ditches are in use. All are planned with the same end in view, but I shall outline three.

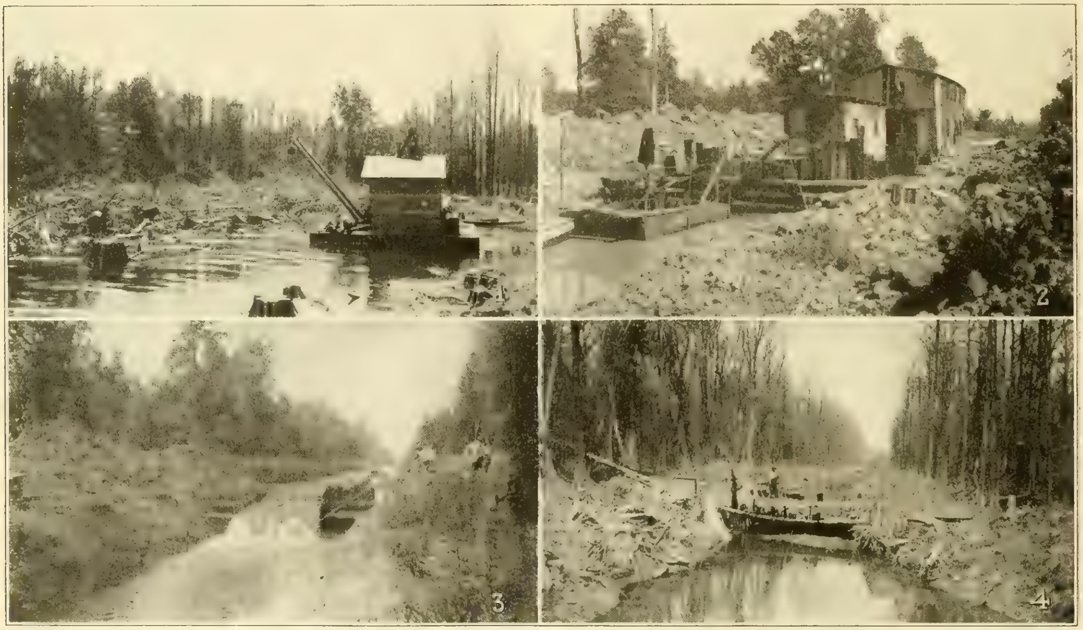
The first is illustrated by Fig. 2. It consists of digging a pilot cut along the center line, taking out approximately 43 per cent of the excavation and depositing it as far back as the reach of the boom will permit. This is continued as far as in the judgment of the contractor it is advisable and then the dredge kicks back and digs out the second cut, which is deposited on the side of the ditch from which that cut is taken. After the second cut is finished, the dredge again kicks back and takes out the finishing cuts along the slope lines. Then by placing the dredge at almost a right angle to the bank line the material on the berms is dug back.

The second method consists of constructing shallow pilot cuts along each berm line, using a small 1-yd. dredge. These pilot cuts are kept considerably in advance of the main excavation so that the excavated material may have ample time to become stable. The main excavation is taken out in two cuts and placed back of the toe formed by the spoil deposited by the pilot dredge. Then the material along the slope lines is taken out.

Method three is quite similar to the first described except that the center is taken out in a single cut and placed on both sides of ditch, the dredge fanning across the ditch to get sufficient reach. The slopes are dug out by placing the dredge at a slight angle to the bank line and at the same time the spoil is cleaned of any timber or debris that may be protruding.

Soil containing a large percentage of sand is sometimes encountered in excavating drainage ditches in the alluvial valley. When this condition was first met it seemed a hopeless job to get a satisfactory channel. It was found, though, that by digging through such reaches and taking out only enough material to float the dredge, then kicking back and removing the remainder of the excavation a very satisfactory channel could be constructed, and this method was thereafter followed.

Wherever it is necessary to work away from the source or supply of water, and especially during the dry season, pumping is required to maintain a sufficient stage to permit operations to continue. The pumping outfit usually consists of a pump and gasoline engine mounted on a barge, so that changes in the stage of the water will not affect the pumping operations, with a discharge pipe of sufficient length to reach over the dam constructed across the ditch to hold the water for the dredge.



Upper Left View—Skidder Mounted on Barge for Clearing Wide Right of Way When Overflowed. Upper Right View—Timber and Canvas Dam—An Economical Construction for Small Ditches, and the Usual Type of Pumping Plant. Lower Left View—Earthen Dam Provided With Spillway. Lower Right View—Hopper Dam.

The dams are usually constructed by placing a log or heavy timber across the ditch at right angle to its center line, driving a sheet piling wall and filling back of it with sufficient earth to give it stability. There are some variations, however. One contractor used a timber and canvas dam quite successfully. This was constructed in the same manner as the one above described except that the wall was stiffened by placing several logs across the ditch and the sheet piling wall was covered with canvas instead of being banked with earth. This type is somewhat more economical than the other, but its efficiency is doubted except for small ditches.

Hopper dams are sometimes constructed. These are made by placing timbers across the ditch at required distances apart, then placing timber walls, inclined at an angle of approximately 30°, against these to form a hopper and filling between with earth. This makes quite a substantial dam. Sheet steel piling driven across a ditch makes a very good temporary dam. The advantage in their use is that it takes much less time and is therefore less expensive to install than the other types mentioned. The piling can be drawn and used over and over again. While figures as to the initial cost of such a dam are not at hand, it is believed that the expense is not much if any in excess of that for constructing a good earthen dam. The only disadvantage in the use of sheet steel piling lies in the fact that they are somewhat difficult to pull and, when the dredge is not available, some special equipment for that purpose must be provided.

Earthen dams are always menaced by the danger of being overtopped during a sudden freshet and this danger has been very ingeniously met by one of our contractors by providing a spillway which will permit a considerable flow to pass without endangering the dam.

It has been the endeavor in this article to outline briefly some of the interesting things in connection with the construction work on this drainage project which is designed to reclaim 488,000 acres of overflow lands in southeast Missouri. The work is in direct charge of Mr. Wm. A. O'Brien, Cape Girardeau, Mo., chief engineer, and Mr. Isham Randolph, Chicago, Ill., is consulting engineer.

PROSPECTING FOR GRAVEL DEPOSITS.

No attempt should be made to develop a gravel deposit without first making thorough tests.

One or two test holes are not enough. Holes should be drilled not more than 200 ft. apart, and 150 ft. apart is preferable. It is better to spend $500 or $1,000 in a preliminary survey than it is to erect a $10,000 plant, perhaps, and then find that the gravel deposit is so light or so scattered that the plant cannot be operated profitably.

The common practice is to employ well drillers to drill the test holes. Six-inch casings are sunk 30 or 40 ft. deep, using an A-frame and improvised driver, or in some cases a blast-hole drilling machine.

An Indiana contractor, in testing for smaller gravel deposits where he has a contract to throw out from 5,000 to 20,000 yd., has devised a simple but satisfactory testing method. One end of a short length of ⅝-in. rod is finished with a chisel edge or barbed point. The rod threads into a 1-in. pipe which is driven into the ground about 10 ft., accompanied by continual turning of the chisel-edged pipe. It is simply a matter of the contractor trusting to his hearing to determine the presence of gravel, and the scheme is entirely satisfactory for testing a small deposit.

COLORIMETRIC TEST FOR ORGANIC IMPURITIES IN SANDS.

Experimental work conducted at the Structural Materials Research Laboratory, Lewis Institute, Chicago, Ill., under the direction of Committee C-9 on Concrete and Concrete Aggregates of the American Society for Testing Materials, indicates that the colorimetric test is a reliable one for discovering organic impurities in sand. The methods of making the test and data obtained in the course of the studies are given by Duff A. Abrams, professor in charge of the laboratory, and Oscar E. Harder, chemist, in a circular issued last month, from which the following is abstracted:

The colorimetric test may be described briefly as follows:

A sample of sand is digested at ordinary temperature in a solution of sodium hydroxide (NaOH). If the sand contains certain organic materials, thought to be largely of a humus nature, the filtered solution resulting from this treatment will be found to be of a color ranging from light yellow up through the reds to that which appears almost black. The depth of color has been found to furnish a measure of the effect of the impurities on the strength of mortars made from such sands. The depth of color may be measured by comparison with proper color standards.

The colorimetric test has been applied to sands from about 40 widely distributed deposits in 20 different states. The research to date has brought out the following:

Examinations of deposits of defective sands show that surface loam is the principal source of contamination.

All natural sands which have been found to be defective on account of the presence of organic impurities have responded to the colorimetric test with sodium hydroxide, and all sands which have given high color values have shown low values in mortar tests.

Sands which were similarly graded by screening out and recombining the different sizes to a definite sieve analysis showed a fairly definite relation between the compressive strengths of 1-3 mortars at 7 and 28 days and the color values of the sands.

The mortar-making quality of sands known to contain organic impurities has been much improved by removing the organic matter, either by repeatedly digesting them with sodium hydroxide and then washing free from alkali, or by driving off the organic impurities by ignition.

When the sodium hydroxide extracts from sands which mortar tests had shown to be defective were purified and applied as coatings on high-grade sand, that sand was made "defective" or gave much reduced mortar strength.

It is impracticable to give exact values for the relation between the color value of a sand and the strength of mortars made from the same sand. However, the tests made thus far show this relation to be about as follows:

Color Values of Sand.	Reduction in Compressive Strength of 1-3 Mortar. Per cent.
250	10-20
500	15-30
1,000	20-40
2,000	25-50
3,000	30-60

The reduction in strength is based on compression tests at ages of 7 days, 28 days, and 3 months, of 1-3 mortars made from the same sand, before and after coating with different per cents of organic impurities which had been extracted from defective sands and purified. Tests on mortars made from defective sands as received and after removal of the organic impurities, either by repeated extractions with sodium hydroxide or by ignition, showed that in some cases the reduction in strength for a given color value was even greater than the higher values given above. Frequently the test pieces completely disintegrated in the storage water. The higher reductions in strength for a given color value for a natural sand as compared with the same color value for an artificially coated sand is probably due to the artificial coating being more easily removed by the sodium hydroxide.

Sufficient data are not available to indicate whether or not the effect of a given quantity of organic impurities varies with the grading of the sand. The reduction in strength seems to decrease slightly with the age of the test pieces.

The concluding remarks in the circular follow:

Impurities in sands other than organic, such as clay or similar admixtures, if present in considerable quantities, may be expected to affect the strength of the concrete. However, the examination of a large number of defective sands has shown that it is the organic impurities of a humus nature which are responsible for the abnormally low strengths of such sands.

It has been found that the colorimetric test can be made with a greater degree of uniformity by different operators than can the strength tests of mortars from the same sands.

The fact that the colors produced by digesting certain natural sands with sodium hydroxide are similar to those produced by treating tannic acid in the same manner must not be interpreted to mean that the organic matter in sands is necessarily tannic acid, or even a tannate. The chemical compounds which make up the organic material are probably numerous and complicated.

The time actually required for a single determination by the laboratory method is about one-half hour. If tests on as many as 5 samples can be made at once, the total time consumed need not exceed 1 hour. The time required from the beginning to the end of the test is about 24 hours.

Inexperienced operators without technical training or previous experience in work of this character have secured satisfactory results at their first trials.

The strength test of mortar is used as the criterion of the effect of impurities in sand. In making strength tests of sand mortars and interpreting the results of such tests, the following points require particular attention:

(a) Sampling of sand,
(b) Grading of sand,
(c) Quantity of water used in mixing,
(d) Methods of mixing, molding and testing,
(e) Form and size of test piece.

(a) Great care is necessary to insure that the sample tested is representative of the larger lot of sand. Good judgment and considerable experience are necessary to secure representative samples from an undeveloped deposit. Some form of sampler should be used in the laboratory in selecting a test sample from a larger lot.

(b) The size and grading has an important influence on the concrete and mortar-making qualities of sands. A sand graded from coarse to fine, with the coarse particles up to about ¼ in. in diameter, is desirable for use in concrete. Fine sands, when mixed to the same plasticity, give mortar strengths much below those of coarse, well-graded sands. The influence of the grading of sand on the strength of the mortar must not be confused with the effect of impurities.

(c) The quantity of water used in mortar tests has just as important an influence on the strength as the amount of cement. The quantity of water required for normal consistency of mortar made from a given cement is a function of the grading of the sand.

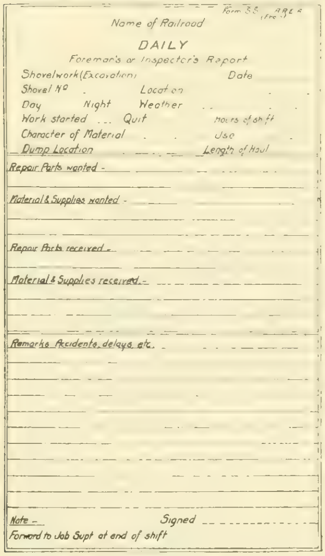
(d) The methods used in mixing, molding the test pieces, storing and testing the specimens, etc., used in standard tests of cement should be followed in making strength tests of sand mortars.

(e) Compression tests of mortar are believed to be more significant than tension tests. A 2 by 4-in. cylinder has been found to give satisfactory results as a compression test piece. This is the form of test piece recommended by the American Society for Testing Materials in their proposed tentative specification for compression tests of cement.

The study of impurities in natural sands is being continued as a part of the work of the Structural Materials Research Laboratory, Lewis Institute, Chicago. Special attention will be given to further improvements in the colorimetric test, and to discovering remedial measures which can be used in a commercial way for counteracting the effects of such impurities.

FORMS FOR REPORTING STEAM SHOVEL OPERATIONS.

The employment of five blank forms for reporting steam shovel operations in railway work is recommended in the 1917 report of the Committee on Roadway of the American Railway Engineering Association. The report is printed in the February Bulletin of the Association, from which the matter that follows is taken.


Form S.S. A.R.E.A. (Front)

Name of Railroad

DAILY

Foreman's or Inspector's Report

Shovelwork (Excavation) Date
Shovel No. Location
Day Night Weather
Work started Quit Hours of shift
Character of Material Use
Dump Location Length of Haul

Repair Parts wanted -

Material & Supplies wanted -

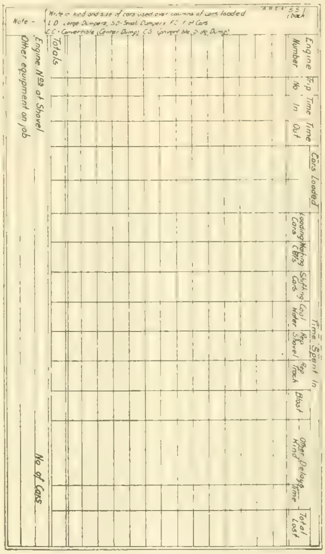
Repair Parts received -

Material & Supplies received -

Remarks Accidents, delays, etc.

Note - Signed
Forward to Job Supt at end of shift

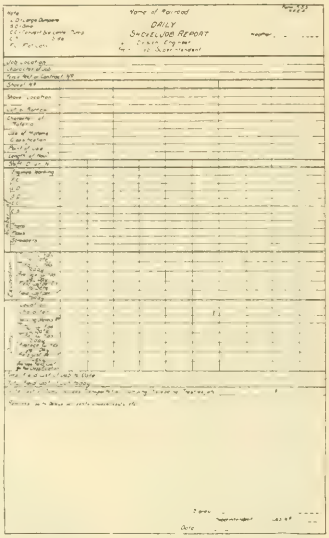
Fig. 1—Steam Shovel, Form 1 (Front).


A.R.E.A. S.S.1 (back)

Note - Write in kind and size of cars used over columns of cars loaded
L.D. Large Dumpers, S.D. Small Dumpers, F.C. Flat Cars
C.C. Convertible (Center Dump) C.S. Convertible (Side Dump)

Engine Number
Trip No.
Time In
Time Out
Cars Loaded
Time Spent in
Blast
Other Delays Kind
Time
Total Lost
Totals
Engine Nos. of Shovel
Other equipment on job
No. of Cars

Fig. 2—Steam Shovel, Form 1 (Back).


Note
L.D. Large Dumpers
S.D. Small
C.C. Convertible Center Dump
C.S. Side
F.C. Flat Cars

Form S.S.3 A.R.E.A.

Name of Railroad

DAILY

SHOVEL JOB REPORT

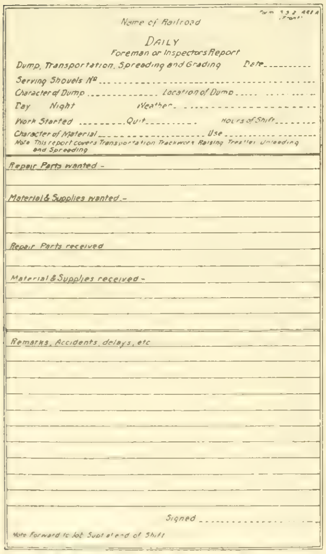
Weather

Job Location
Character of Job
Force Acct or Contract No.
Shovel No.
Shovel Location
Cut or Borrow
Character of Material
Use of Material
Classification
Point of use
Length of Haul
Shift D or N
Engines Working
F.C.
L.D.
S.D.
C.C.
C.S.
Trains
Plows
Spreaders
Excavation
Total Field Cost of Job to Date
Remarks

Signed
Superintendent
Date

Fig. 5—Steam Shovel, Form 3.

The recommended forms are shown in the accompanying illustrations. Of the shovel forms recommended, the first two, S. S. 1 (Figs. 1 and 2) and S. S. 2 (Figs. 3 and 4), are the reports of the shovel and dump foremen, if the work is done by the railroad forces, or the inspectors, if it is a contract job. They deal purely with field conditions and are to be made out on the work, mainly while it is in progress. The front of the form, besides certain information shown as required at the top, provides space for repair parts, materials and supplies wanted and received and remarks which should act in the nature of a diary. The back is devoted to a tabulation of data and information covering the most important features of operation. Everything on this report, as far as possible, should be checked against the records of the timekeepers, storekeepers, etc., in the job offices. The size of the form is designed, when bound in a book, to fit comfortably into a man's pocket. These forms should be printed on good quality blue and yellow paper, respectively, and bound in books with stiff board covers, opening endwise. The sheets should be perforated at the top so that the forms may be torn out readily when completed. These forms should go to the job superintendent, or whoever is in immediate charge of the piece of work, and should also be accessible to the master mechanic or person in charge of the job plant as well.


Form S.S.2 A.R.E.A. (Front)

Name of Railroad

DAILY

Foreman or Inspectors Report

Dump, Transportation, Spreading and Grading Date..........
Serving Shovels No. ....
Character of Dump .... Location of Dump ....
Day Night Weather ....
Work Started .... Quit .... Hours of Shift ....
Character of Material .... Use ....
Note This report covers Transportation Trackwork Raising Trestles Unloading and Spreading

Repair Parts wanted -

Material & Supplies wanted -

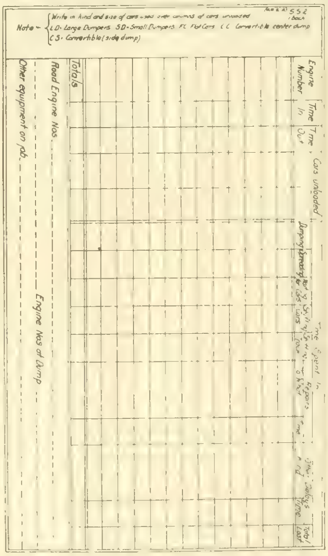
Repair Parts received

Material & Supplies received -

Remarks, Accidents, delays, etc

Signed ....
Note Forward to Job Supt at end of Shift

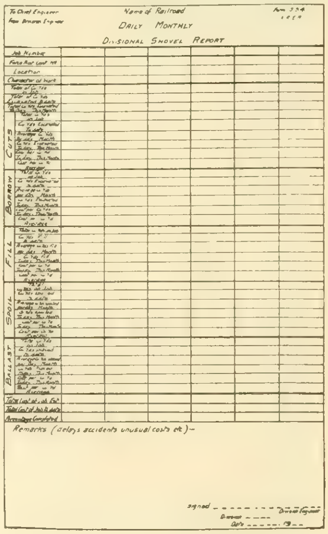
Fig. 3—Steam Shovel, Form 2 (Front).


A.R.E.A. S.S.2 (back)

Note - Write in kind and size of cars used over columns of cars unloaded
L.D. Large Dumpers S.D. Small Dumpers F.C. Flat Cars C.C. Convertible center dump
C.S. Convertible (side dump)

Engine Number
Time In
Time Out
Cars unloaded
Time Spent in
Repairs
Other Delays Kind
Time
Total Lost
Totals
Road Engine Nos.
Engine Nos. of Dump
Other equipment on job

Fig. 4—Steam Shovel, Form 2 (Back).


To Chief Engineer
From Division Engineer

Form S.S.4 A.R.E.A.

Name of Railroad

DAILY MONTHLY

DIVISIONAL SHOVEL REPORT

Job Number
Force Acct Cont No.
Location
Character of Work
Cuts
Borrow
Fill
Spoil
Ballast
Total Cost of Job Est.
Total Cost of Job to date
Percentage Completed

Remarks (delays accidents unusual costs etc)—

signed .... Division Engineer
Division ....
Date .... 19..

Fig. 6—Steam Shovel, Form 4.

When Forms S. S. 1 and S. S. 2 have been received from the various units of the job, the distribution clerk compiles Form S. S. 3 (Fig. 5) based on the information they contain, and from the records of the timekeepers, storekeepers, etc. This is laid before the job superintendent, or similar official, to be approved, signed and forwarded to the division engineer, or whoever has charge of that division or district. These figures should include everything chargeable to the job, including labor, clerical and engineering staff, material, plant and overhead of the job proper.

At the end of each month, Form S. S. 5 (Fig. 7) should be made out and forwarded, as described in S. S. 3. This is merely a monthly summary of the S. S. 3 reports.

When the S. S. 3 forms have been received from all the different jobs of that division or district, the distribution clerk of that office compiles the report shown in Form S. S. 4 (Fig. 6). This summarizes the information contained in the S. S. 3 forms and is built up in combination with the previous S. S. 4 forms, so that each interlocks with the one preceding and that immediately following it. When Form S. S. 4 is completed, it is laid before the division engineer or other proper official for his approval and signature, after which it is forwarded to the chief engineer or vice-president in charge of construction and maintenance. In making out their report in daily form, the word "month" should be everywhere crossed out.

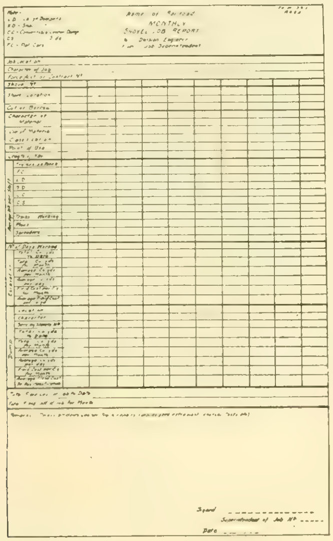


Fig. 7—Steam Shovel, Form 5.

At the end of each month a monthly report should be made on the same form, S. S. 4, crossing out the word "day" where month appears and takes its place. This form is made up from the S. S. 3, 4 and 5 reports just received and forwarded as described for the S. S. 4 forms.

In Forms S. S. 3 and S. S. 4 average yardage costs are given beside the daily or monthly yardage cost, so that the difference may be seen at a glance as to whether the cost is increasing or decreasing, and explanations be immediately in order. The partial individual summaries of work done also shows the proportion of work completed without the usual analysis and arithmetic.

These forms are designed for use on not over 2-shift work. Where three 8-hour shifts are used, the forms may be readily altered to suit. No telegraphic report forms are recommended. If such are desired, they must necessarily be so brief and simple that their preparation from these illustrated is so simple that special recommendation is not thought necessary.

If certain costs show increases that are not accounted for in the report, details may be secured from the distribution clerk, who should have all the individual items going to make up these costs posted and accessible in his distribution book. In the same way, details as to the cost of repairs to different pieces of equipment, the cost of individual supplies, etc., may be secured in the same manner. The distribution clerk should get his data daily from the timekeepers, storekeepers, etc., and should balance up with these separate departments every month. On contract work he should be given access to the above records of the contractor, if such reports are desired. If possible, the man selected for this work should be so constituted that he can maintain amicable relations with the contractor's men under trying circumstances.

U. S. RECLAMATION SERVICE SPECIFICATIONS FOR DRAGLINE EXCAVATORS.

The U. S. Reclamation Service, through its Denver, Col., office, is asking proposals for furnishing dragline excavators. Bids will be received on machines with different types of internal combustion engines, and contracts may be awarded for two, three or four machines, which may be of the same type or of different types, at the option of the United States. Extracts from the specifications are given below.

General Description. The dragline excavators shall have a 50-ft. boom and be designed to operate with a $1\frac{1}{2}$ cu. yd. bucket. A machine of rigid construction and high operating speed is desired. All members shall be bolted or riveted in such a manner that rivets or bolts will not work loose under the most severe conditions of operation. Cast steel shall be used wherever practicable. The swinging gear shall allow for at least 180 degrees swing in both directions from the central point, and the construction and design shall be such that the reverse may be applied when swinging full speed. The machines shall be mounted on a power-driven caterpillar traction device of ample bearing surface for water-logged or marshy soil. The turntable rollers shall have machine treads. The boom and A frame shall be of steel construction. The sheaves and drum shall be of sufficient size to avoid excessive wear on the cables. Sheaves shall preferably be of annealed steel with turned grooves and bronze bushing. All brake and friction surfaces shall have sufficient area to avoid necessity of frequent renewals. All shafting shall be of ample size to stand sudden application of the brakes or power. Gearing should preferably be of steel with teeth cut from the solid. The operating levers shall be so located that the operator will have an unobstructed view of the work. A complete set of wire ropes, including digging, hoisting, boom and swinging ropes, if necessary, shall be furnished. The ropes shall be of the best grades for this class of work.

Engines.—The machines shall be driven by internal combustion engines using distillate, gasoline or kerosene for fuel. Engines of the multi-cylinder type are preferred. A suitable starting system shall be provided for starting the engine without cranking by hand. In the design of the engine, particular attention should be given to accessibility, ease and cheapness of making repairs and adjustments. The engines shall have sufficient power to swing and hoist a loaded bucket simultaneously and to handle the work easily without danger of being stopped due to sudden application of the load. The engines shall be provided with a cooling system and tank for the circulating water of ample capacity for the satisfactory operation of the engine at 130° air temperature. A fuel tank and all appurtenances necessary for operation shall be provided. The engines should be designed for operation at an elevation of 3,500 ft. above sea level.

Lighting Sets.—The electric generating sets required shall be of approximately 1½ k.w. capacity. A 32-volt direct-current generator is desired, but 110 volts will be considered. A switchboard with necessary instruments and switches shall be furnished. The generator shall be driven by a separate gasoline engine, preferably direct connected, or from the main engine with a storage battery and a regulator to keep the voltage constant.

Design and Construction.—It is the intention of these specifications on all points whether or not specifically covered herein to obtain apparatus of first-class engineering design, material and workmanship which has proven best suited for the purpose for which it is to be used, and which represents the best modern practice in design and construction of working parts. Like parts shall be interchangeable. The contractor shall guarantee the designs, material and workmanship furnished by him to be free from defects. He shall replace, free of cost to the United States, any such defective material or apparatus that shall develop faults due to design, material or workmanship within six months of starting operation thereof on the project.

Painting.—All parts of the machinery shall be thoroughly painted before being shipped.

Test Conditions. The material to be excavated will be sandy loam with a depth of cut of 8 to 10 ft., bottom width of trench of 8 to 12 ft. and side slopes [illegible]; machine to be set on center line of ditch on level ground and dirt to be deposited at maximum distance from the ditch. The bucket used will be a Page type, $1\frac{1}{2}$ cu. yd. capacity, the test to run for a period of eight hours, which shall include necessary moving of machine. The fuel used in test will be as follows:

Distillate engine driven machine, Distillate Gravity Baume
48-52 B. T. U. per lb. [illegible]
Gasoline engine driven machine, Gasoline Gravity Baume
58-60 B. T. U. per lb. [illegible]
Kerosene engine driven machine, Kerosene Gravity Baume
43-44 B. T. U. per lb. [illegible]

DRAG LINE EXCAVATION METHODS IN CONSTRUCTION OF WINNIPEG AQUEDUCT.

Much of the excavation in connection with the construction of the 85-mile concrete aqueduct for the Greater Winnipeg Water District of Winnipeg, Man., is being carried out by means of drag line excavators. The aqueduct is horseshoe shaped and will be covered with a minimum of 4-ft. back fill for frost protection. The conduit runs through a flat and poorly drained country. The first 25 miles of the line from Winnipeg extends through open prairie; the next 15 miles traverses wooded and rolling prairies and the remaining 45 miles runs through wooded bog or peat covered country. It is on the last section that the drag lines described in this article are being used. This section comes under Contracts 32, 33 and 34, awarded in October, 1914, to the Winnipeg Aqueduct Construction Co. of Winnipeg, Man. The approximate quantities for some of the principal items in these contracts and the unit bidding prices were as follows:

	Contract 32. Cu. yd.	Price.	Contract 33. Cu. yd.	Price.	Contract 34. Cu. yd.	Price.
Top soil excavation.....	15,000	$0.30	13,000	$0.30	2,000	$0.30
Earth excavation	358,000	.55	371,000	.55	789,000	.55
Rock excavation	9,000	3.00	4,000	3.00	1,000	3.00
Refill and embankment.	390,000	.25	314,000	.25	288,000	.25
Foundation embankment	98,000	1.50	13,000	1.50	36,000	1.50
Timber and lumber*....	†1,600	.45	†1,700	.45	†2,400	.45
Concrete in aqueduct...	65,700	9.90	65,600	9.90	72,000	9.90

*Furnished and ordered left in place. †M. ft. B. M.

A considerable part of the excavation under these contracts is in clay overlaid with muskeg material. This work is being carried out by specially designed drag line excavators, provided with superheaters to obtain full economy from the coal.

The procedure, in general, in constructing the aqueduct is as follows: The trench is excavated to about 6 in. of the bottom of the invert. Then just before the concrete for the invert is placed, the remaining 3 in. of earth is trimmed off by hand excavation. The invert is then poured in 15-ft. lengths and following this the arch sections are poured in 45-ft. lengths.

The drag lines commonly stand at the end of the trench and work backwards, the material being dumped along the south side in most cases to form an embankment to carry a narrow-gage construction track for use of trains conveying concrete to the work. The mixing plants on these contracts are located adjacent to the contractor's storage platforms on the standard-gage construction railway built by the Water District paralleling the line of the aqueduct. The narrow-gage tracks extend from the mixing plant along the aqueduct spoil bank for a distance of about ½ mile in each direction. The concrete is hauled to the work by small dump cars drawn by gasoline-driven locomotives, and is chuted from the cars to the forms in the trench.

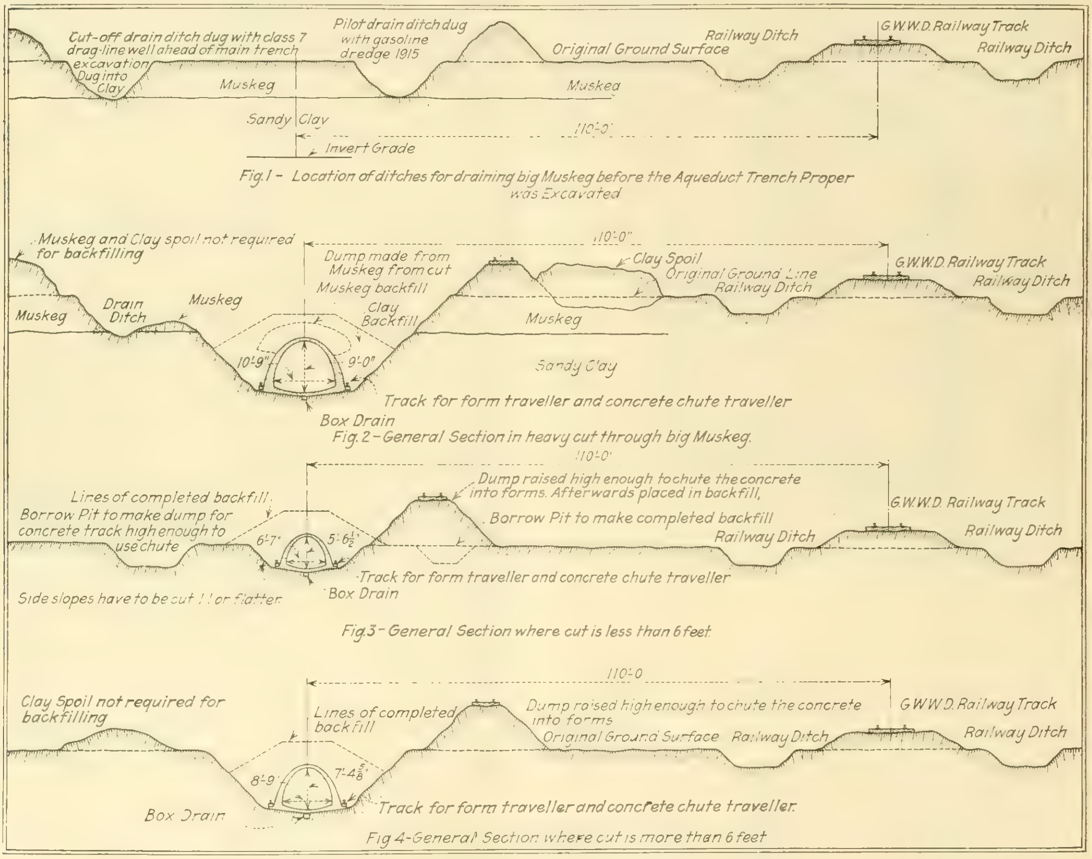

Cut-off drain ditch dug with class 7 drag-line well ahead of main trench excavation
Dug into Clay
Pilot drain ditch dug with gasoline dredge 1915
Original Ground Surface
Railway Ditch
G.W.W.D. Railway Track
Railway Ditch
Muskeg
Muskeg
Sandy Clay
110'-0"
Invert Grade
Fig. 1 - Location of ditches for draining big Muskeg before the Aqueduct Trench Proper was Excavated
Muskeg and Clay spoil not required for backfilling
Dump made from Muskeg from cut
Muskeg backfill
Clay Backfill
110'-0"
Clay Spoil
Original Ground Line
Railway Ditch
G.W.W.D. Railway Track
Railway Ditch
Muskeg
Drain Ditch
Muskeg
Muskeg
10'-9"
9'-0"
Sandy Clay
Track for form traveller and concrete chute traveller
Box Drain
Fig. 2 - General Section in heavy cut through big Muskeg.
110'-0"
Lines of completed backfill
Borrow Pit to make dump for concrete track high enough to use chute
Dump raised high enough to chute the concrete into forms. Afterwards placed in backfill
Borrow Pit to make completed backfill
G.W.W.D. Railway Track
Railway Ditch
Railway Ditch
6'-7"
5'-6½"
Track for form traveller and concrete chute traveller
Box Drain
Side slopes have to be cut 1:1 or flatter
Fig. 3 - General Section where cut is less than 6 feet
110'-0
Clay Spoil not required for backfilling
Lines of completed backfill
Dump raised high enough to chute the concrete into forms
G.W.W.D. Railway Track
Original Ground Surface
Railway Ditch
Railway Ditch
8'-9"
7'-4⅝"
Track for form traveller and concrete chute traveller.
Box Drain
Fig 4 - General Section where cut is more than 6 feet

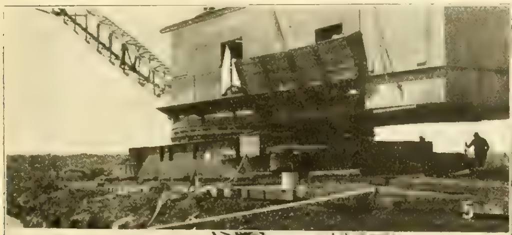
Fig. 1-4—Method of Operation in Excavating With Draglines for Trench of Congrete Aqueduct of Greater Winnipeg Water District.

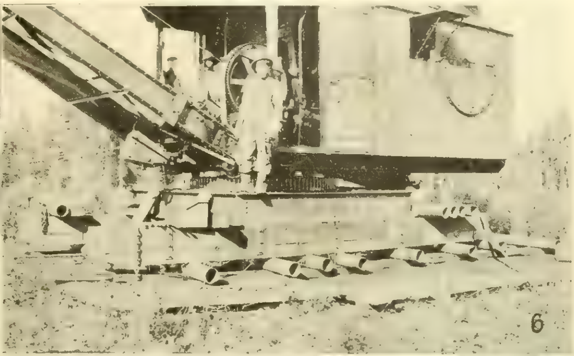
The method of operation is shown by Figs. 1 to 4. On certain sections of the work, as indicated by Fig. 1, it was necessary to drain out the muskeg before beginning on the aqueduct trench. This was done by means of a pilot ditch dug the year before with a gasoline dredge. A cut-off drain ditch also was excavated with a small drag line, this work being kept well ahead of the main trench excavation.

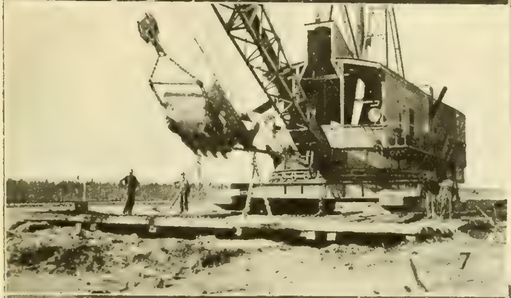
Ten drag lines are being used by the Winnipeg Aqueduct Construction Co. on its three contracts. These machines were made by the Bucyrus Co., and are of various sizes. Seven of them are the Class 7 Bucyrus drag line. There also are one Class 14, one Class 20 and one Class 24. The drag lines are supported on the bog on timber platforms. The pads for the Class 24 are 9 ft. wide by 38 ft.

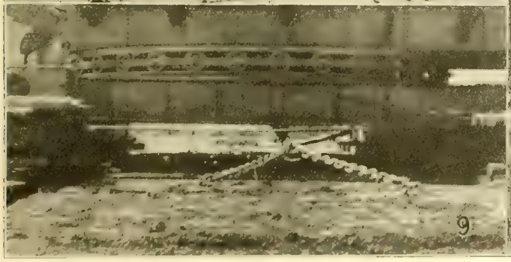
long, made up of 8-in. by 12-in. 38-ft. long timbers and weigh over 7 tons. The illustrations, Figs. 5 to 9, show the supports and method of moving them.

The Class 24 drag line has a 110-ft. boom and a 3½-yd. bucket and is intended for use in wide and deep cuts. Some of these, it is expected, will have a top width of at least 90 ft. and a depth of 26 ft. This machine was started last year on a trench having a top width of 70 ft., a 20-ft. bottom, and a depth varying from 10 to 20 ft.









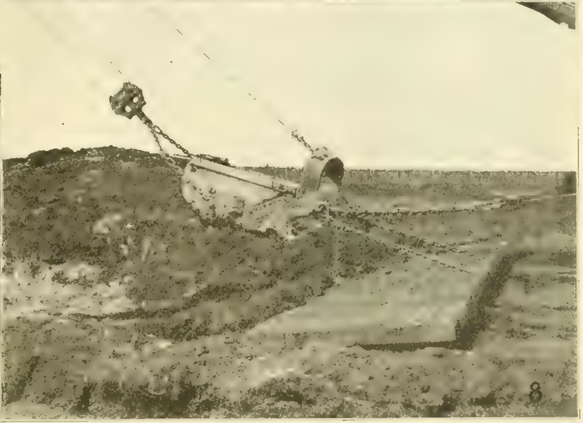
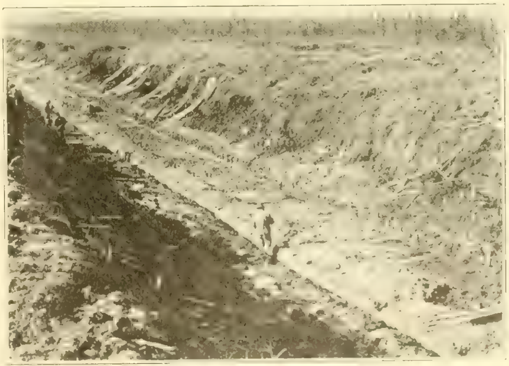


Fig. 5—Platform and Rollers for Class 24 Drag Line. Fig. 6—Pads and Rolls for Class 7 Drag Line. Fig. 7—Class 24 Getting Ready to Move Up. Fig. 8—Method of Moving the Pads for the Class 24. Fig. 9—Hold Back on Class 14 to Prevent Slipping Into Ditch. This Consists of 1¼ In. Chain Attachment to U Bolts in Pads.

The Class 14 drag line has a boom 70 ft. in length and is worked on sections where the cuts run from 12 to 17 ft. Last season this machine was working through a stretch of muskeg averaging 15 ft. in depth. In this work the first excavation was carried down 5 ft. to 7 ft., which was about as deep as the sides would stand without sliding. The machine would excavate a stretch at this depth and then return and carry down the cut a little deeper. Between the cuts the sides would drain and compact and eventually the ditch would be excavated to grade. Three or four cuts were necessary in most cases, but on one stretch, owing to slides, caused mostly by rains, it was necessary to go over the ground eight times. Fig. 11 shows the Class 14 machine excavating muskeg at mile 85.

The Class 20 machine has an 85-ft. boom and a 2½-yd. bucket and is used mainly on excavation where the cut does not exceed 18 ft. and the top width of trench is not greater than 65 ft. This drag line was used this winter in concreting and mucking at Falcon River. In the latter work the machine hoisted hand-loaded buckets out of the trench. The illustration, Fig. 12, shows the Class 20 excavating along the shore of Snake Lake.

The trenching on this section was conducted under some difficulties last summer owing to the high water. about ¼ mile of aqueduct line at a time. This area was There was 3 to 4 ft. of water over the line of the aqueduct with most of the bog floating in it. This problem was solved in the following manner: A small gasoline dredge was installed on a scow. With this a cut was made on the lake side of the aqueduct line, the spoil being deposited so as to make a dike around an area taking in pumped out with centrifugal pumps so that the Class 20 drag line could get over the surface of the muskeg. This machine deposited enough heavy spoil from the bottom of the trench on top of that placed by the dredge, to compress the muskeg sufficiently to allow the pumping out of the trench and the placing of the aqueduct.



Trench in Muskeg Showing Use of Stakes and Brush Along Bottom Edge of Cut to Support Excavated Material.

The small drag lines, Class 7, are used for back filling, digging drainage ditches, excavating the main trench and other purposes. Fig. 13 shows one of these machines working in firm material. These machines are frequently moved to different sections of the 47 miles of aqueduct included in the contracts. In making these moves advantage is taken of the standard-gage construction railway of the Water District running along the line of the work. For short distances the drag line is mounted on a low truck made of two 10x18-in. bridge timbers set on a couple of heavy axles carrying low-flanged wheels. These axles run loose in channel irons so that the curves in the railway can be made easily. The channel irons are bolted to the timbers and the wheels run loose on the axles. The drag line pulls itself along, the rollers, pads, etc., being loaded on push cars behind. Where long moves are to be made the drag line is placed on flat cars and attached to trains. The methods employed in getting the machines on the car depends on conditions. Where the car is not too high above the ground level, the drag line digs and builds a slight incline to the car up which it climbs in the usual manner. The usual way is to run the machine onto the track on its skids and rollers and then jack it up and slide it on the car. In some cases an incline is built of timbers or logs. The drag line then pulls itself up this incline either by attaching a cable to a tree or by hooking the bucket on the side of the car.

Drag lines are also used in placing the back fill over the concrete aqueduct, as is illustrated in Figs. 14 and 15. In this work the material placed by the machine has to be deposited carefully so as not to cause any shock to the concrete structure. It is stated that the material placed in this way makes a much more compact mass than can be obtained by hand tamping.

The contracts of the Winnipeg Aqueduct Construction Co. are being carried out under the general superintendency of William Smaill.

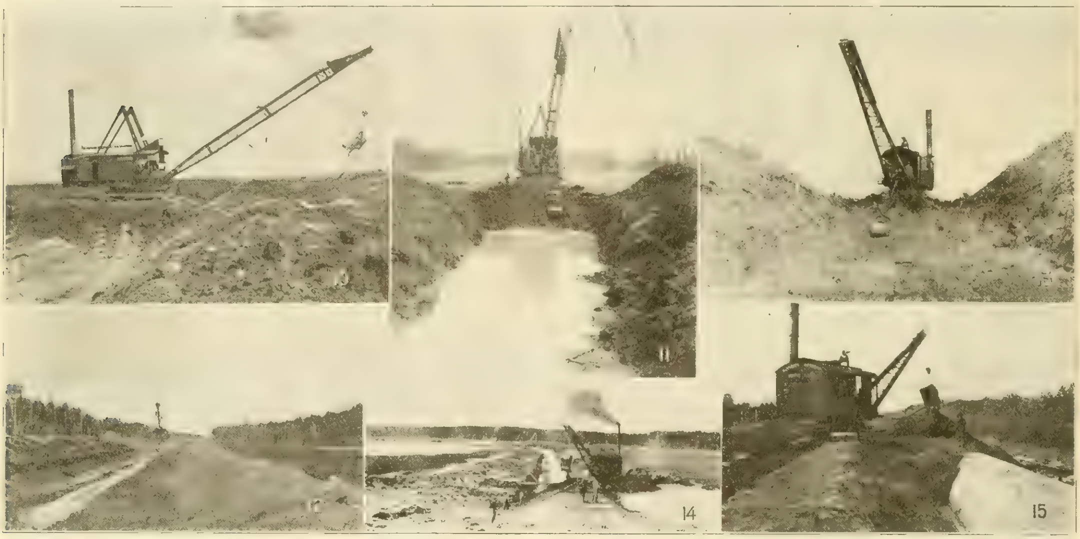


Fig. 10—Class 24 Drag Line Working in Cut Consisting of 8 Ft. Muskeg and 9 Ft. Clay. Pilot Ditch May Be Seen in Background. Fig. 11—Class 14 Drag Line Excavating in Muskeg. Fig 12—Class 20 Drag L ineExcavating Along Shore of Snake Lake. Floating Bog May Be Seen Outside Dirt Dike. Fig. 13—Class 7 (30 Ton) Drag Line Wroking in Firm Material. Fig. 14—Backfilling Aqueduct at Indian Bay. Cut Run Through Deep Bog and Conduit at This Point Follows Shore Line of Bay. Fig. 15—Backfilling With Class 7 Drag Line. Fig 16—Section of Aqueduct Backfilled With Drag Line.

Sizes of Steam Shovels.—In its annual report for 1917 the Committee on Roadway of the American Railway Engineering Association gives the following gradient of sizes for steam shovels for use in railway work: For light grading, up to 25,000 cu. yd. per mile, where a shovel can be used economically, a light revolving shovel is to be desired. For 25,000 to 40,000 cu. yd. per mile, a shovel of about 50 tons is a good size. For 40,000 to 60,000 cu. yd. per mile, a shovel of 60 to 80 tons is well suited. For anything over 60,000 cu. yd. per mile, the shovel may run up to well over 100 tons economically if its transportation is not too expensive.

OPERATING COSTS OF MOTOR TRUCK IN DELIVERING SAND AND GRAVEL.

A Pacific Coast sand and gravel company is using a 5-ton truck for delivering sand and gravel. The material is nearly always mixed and usually is quite wet. It runs 4 yds. to the load and 3,400 lbs. to the yard, and is hauled over country roads of various kinds, about equally divided between gravel and dirt. There are many hills, some of them quite steep, necessitating going in first and second gears. Most of the trucking was for delivering gravel on county roads, and spreading it with the attachment on the truck. The following operating costs, furnished by the company, cover a 5-months period last year:

OPERATING COSTS, 5-TON TRUCK, 4-YARD CAPACITY.

Article used.	Amount gal.	Miles per gal. or lb.	Cost per mile.	Av. cost article.	Total cost.
Distillate	1,655	3.494	$0.0153	11†	$ 182.05
Gasoline	606	3.494	.023	21†	121.20
Motor oil	133	59.4	.0052	31†	41.23
Transmission oil	249*	31.7	.0017	5½‡	13.48
Sprocket oil	144	55	.0012	7†	10.08
Cup grease	100*	79	.0006	5‡	5.00
Tire replacements and depreciation	...	......	.0196	..	154.93
Repairs and parts	...	......	.0026	..	21.06
Wages	...	......	.057	..	508.75
Interest (8 per cent)	...	......	.0276	..	218.78
Depreciation (20 per cent)	...	......	.05	..	394.66
	...	......	$0.2038	..	$1,671.22

*Pounds. †Ct. gal. ‡Ct. lb.

FOR THE SEASON.

Average distance of delivery, miles	6.1
Cost per yard mile	$0.1055
Cost per ton mile	.0617
Total mileage	7,900
Yards delivered	5,190
Weight of gravel, 1 yd., lb	3,400
Yard miles hauled	15,800
Ton miles hauled	28,835

Method of figuring:

$$\frac{\text{Miles per day}}{2} \times \frac{\text{yards}}{\text{tons}} \quad \frac{\text{yards}}{\text{tons}} \text{ per day}$$

—or—

$$\frac{\text{Miles per trip}}{2} \times \frac{\text{yards}}{\text{tons}} \quad \frac{\text{yards}}{\text{tons}} \text{ per trip}$$

The truck was new last year. The driver was paid for an extra hour each day the truck was operated. This extra time he put in screwing down the grease cups and inspecting parts on the truck. The driver was, therefore, held responsible for anything happening that could have been prevented by his inspection. In several instances he discovered that there was a loose nut, missing bolt, cup gone or something of minor importance, which if neglected might cause lost time and more or less expense.

These things were immediately attended to and as a consequence no time was lost on account of truck trouble.

SETTLING BOX MAKES SAVING IN HANDLING SAND.

Considerable saving in the expense of handling of sand and gravel is effected at the plant of the Seguine-Bogart Co., Kenvil, N. J., by means of a settling box. This gravel and sand screening and washing plant, is practically a reconstruction of an old drag line excavator plant. It was desired to increase the capacity of the plant, and dig by means other than the drag line bucket. A pit had been dug large enough to store sufficient water to make pumping feasible. A scow was built, on which was mounted the boiler, engine and centrifugal pump.

Sand and gravel are sucked up and delivered to the foot of the washing and screening plant through a 6-in. pipe. The pipe discharges into a large wooden settling box, or separator, by means of which the sand is delivered to a slow-moving, double-strand discharge elevator, the water overflowing and returning to the pit.

Material is elevated high enough to deliver to a chute, down which it is washed to the shaking screens. A further separation of the sand and water is effected by a counterweighted separator at the top of the bin, from which the product is delivered direct to railroad cars.

Plant of Seguine-Bogart Co. at Kenvil, N. J.

The new equipment was designed and built by the Link-Belt Co., Philadelphia and Chicago. The separation of sand and water at the foot of the elevator saves expense in handling, inasmuch as nothing is elevated but sand and gravel. The power which would be required to pump water and sand to the top of the plant is saved. The entire plant is operated by five men. It has a capacity of approximately 1,000 yd. in 10 hours. A plant of this type is best suited to material consisting largely of sand, with few pebbles, as the sand is more easily sucked up and delivered by means of the centrifugal pump than the pebbles, which, being heavier, are not so readily handled by the pump.

Replacing Wooden Frame of Gravel Bins with Concrete.—The Barnes Sand & Gravel Co. of Piketon, O., plans to replace its present framework structure with concrete bins and has devised a way to make the change without much interruption of operations. The framework of the present bins will be made to serve as the inside forms for the concrete walls of the new bins. The present conveyor system will remain intact, but the present output capacity of 20 cars a day will be doubled by the installation of Dull inclined conical screens, replacing the older type of Dull horizontal screens.

Cost of the Rogers Pass Tunnel.—In the Feb. 21 issue of Engineering and Contracting it was stated that the cost of the recently completed Rogers Pass Tunnel of the Canadian Pacific Railway was about $6,500,000. Mr. A. C. Dennis, the general superintendent for the contractors for this work, calls our attention to the fact that this figure covers the entire improvement, which included considerable line outside the tunnel. He states that the cost of the tunnel proper, for excavation, concreting, etc., inclu[d]ing contractors' profits, was below $150 per foot.

METHOD OF BREAKING UP FROZEN COVERING ON STRIPPING JOBS.

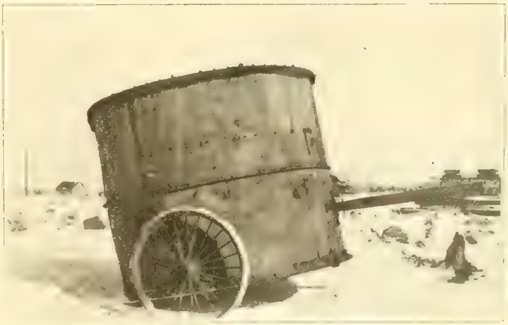
Contributed by Arthur E. Anderson

Owing to the lack of snow and the extreme temperature early in the season, the frost on the Mesaba Range, Minnesota, has penetrated to a depth of 6 ft. or more. It has been necessary to break up this frozen covering on stripping jobs, and due to the fact that the work has been within city limits, heavy charges became prohibitive, and a large number of light charges fired in close succession were necessary. The problem resolved itself then into one of getting the holes down rapidly and cheaply.

To do this a steam jet was called into action, and the results were very gratifying, as two men could "jet" and charge the holes as rapidly as needed, or about 205-ft. holes per 10-hour shift.

Steam Jetting Arrangement.

The machine is very simple, consisting of a 5½-ft. length of 1-in. pipe, a valve, elbow and nipple. A handle is clamped to the pipe and a circular wooden guard to protect the workman from sputtering mud completes the arrangement. Steam is taken from the shovel in iron pipes, as it was found that steam hose could not stand up long enough under hard service to warrant its use; just enough hose is attached to give the "jet" the working radius desired. A possible advantage in this method lies in the fact that in extreme weather from 20° to 30° below zero the powder is very apt to become frozen, but when put into the heated hole and left for a time, the powder thaws and the full efficiency is realized.



Tank for Covering the Blast.

Due to the fact that the pedestrians and traffic had to be protected from flying frozen chunks, and because blasting was necessary any hour of the day, some means to facilitate this work had to be evolved, and the result was the "tank." The "tank" was originally a shelter house, and is constructed of ¼-ft. steel. The conical roof was removed and replaced with a No. 12 wire screen, ½-in. mesh, and the screen reinforced by iron rods at right angles. The entrance was closed in the same manner, and the whole mounted on wheels and a handle attached to pull it around.

The "tank" is 10 ft. in diameter, and is pulled into position by four or five men. All holes are electrically fired by a battery, the men standing around while this is being done. As soon as a shot was fired, the tank is moved to the next hole and the operation repeated. In this manner the frost layer is broken up so that the shovel could handle it, without inconvenience to workmen or the public, not a single accident from this operation having been recorded during the entire winter.

STANDARD SIZES OF STONE AND GRAVEL FOR USE OF WISCONSIN HIGHWAY COMMISSION.

Standard sizes of stone and gravel for use in all state and state-aid construction have been adopted by the Wisconsin Highway Commission. This standardization is the result of conferences between the Commission, the Crushed Stone Producers' Association, the Wisconsin Society of Engineers and the State Chief Engineer. The members of the Crushed Stone Producers' Association have agreed that as they renew their screens they will install screens so that they can furnish materials complying with these standards. The State Highway Commission points out to both stone and gravel producers that it believes that this standardization, reducing as it does the number of screen sizes in many cases, should enable them to put in longer screen lengths for each standard size and thus secure a better separation of the materials, especially in the small sizes.

The state standard sizes and numbers are as follows:

No. 1. Material retained on a 2-in. circular opening and passing a circular opening not greater than 3½ in. in diameter.

Note: Plants may furnish as No. 1 material the product retained on a 2-in. circular screen and passing a circular screen 3½ in. or less in diameter.

No. 2. Material retained on a 1-in. circular opening and passing a 2-in. circular opening.

No. 3. Material retained on a ½-in. circular opening and passing a 1-in. circular opening.

No. 3½. Material retained on a ¼-in. circular opening and passing a ½-in. circular opening.

No. 4. All material passing a ¼-in. circular opening.

In the future state specifications from commercial plants will call for No. 1 stone for first course of macadam; No. 2 stone for the second course of macadam, and No. 4 for screenings. Nos. 3 and 3½ will not be used in new macadam construction except that possibly No. 3½ may be used for preliminary screening in certain cases.

For 1-course concrete roads, state specifications will call for material retained on a ¼-in. screen and passing a 2-in. screen, with no intermediate size removed, being a combination of all materials included in Nos. 2, 3 and 3½.

Note: A passing screen smaller than 2 in. may be used for gravel, quartzite, granite and trap rock aggregate, provided it is not less than 1¼ in.

For 2-course concrete work the state specifications will call for first course, coarse aggregate the same as for 1-course concrete. The second course, coarse aggregate will consist of material retained on a ¼-in. screen and passing a 1-in. screen, with no intermediate size removed, being a combination of Nos. 3 and 3½.

For use in absorbing surface treatments on macadam roads for first application No. 3½ is recommended; for further applications either No. 3 or a combination of No. 3 and No. 3½. Do not use No. 4, which contains fine sand or dust for absorbing purposes.

The state standard for sand will be all material passing a ¼-in. screen, provided that not more than 20 per cent shall pass a sieve having 50 meshes per linear inch, and not more than 5 per cent shall pass a sieve having 100 meshes per linear inch.

It will be noted that the five sizes specified will ordinarily be separated in the process of production, but that it is possible, by remixing these sizes, to produce materials meeting a large number of specifications, and the range of sizes thus secured is believed to be adequate for all architectural and engineering purposes.

ILLINOIS COMMISSION PROTESTS TENTATIVE VALUATION OF ELGIN, JOLIET & EASTERN RY.

The State Public Utilities Commission of Illinois has filed with the Interstate Commerce Commission a protest against the tentative valuation of the Illinois properties of the Elgin, Joliet & Eastern Ry., as reported by the latter commission on Feb. 12, 1917.

In support of its protest the State Public Utilities Commission of Illinois alleges that the engineering report contains, among other things, inaccuracies and erroneous assumptions, such as the following:

Unit Prices: Certain unit prices are considered excessive, as, for examples, $3 per cubic yard for slag riprap; $29 per ton for cast iron pipe, regardless of size; and $7.75 per cubic yard for plain concrete.

Lack of Detail: Lack of detail prevails throughout the report. While the necessity of brevity is recognized, nevertheless sufficient information should be given so that a clear idea may be formed of the various items of property. Examples of this lack of detail are found in the inclusion of fixtures and furniture with the value of the containing building; or water and sewer lines with tanks; in valuing depot buildings in groups, instead of separately; in telegraph, telephone, transmission and distribution systems; in the omission of the ages of many structures; in the failure to state the method by which taxes were determined; and in many other cases of like character.

Engineering: Engineering allowances were determined by taking 4.25 per cent of the totals of certain accounts, and the amounts so obtained were not depreciated. The Illinois Commission maintains that: 4.25 per cent is too large and that the allowances would be more nearly represented by 3.3 per cent of the accounts. The allowances for engineering should be determined by estimating the cost of a sufficient organization to perform properly the required engineering services, and not by taking a percentage of certain accounts. Engineering should be depreciated to the same extent as the article of which it forms an element of value.

Shrinkage: Allowances of 10 per cent of the quantities contained in embankments, and totaling 431,333 cu. yd. in Illinois, were made for so-called shrinkage of earthwork. Any and all allowances for such shrinkage are protested as being unwarranted and contrary to fact.

Subsidence: Allowances totaling 423,706 cu. yd. in Illinois were made because of alleged subsidence of roadbed. These allowances are equivalent to a portion of the average roadbed of this carrier approximately 41 miles long and are considered excessive and contrary to fact.

Sub-ballast: The engineering report states that sub-ballast is separately itemized and allowed for at the price of earth excavation. As a matter of fact, sub-ballast is not separately itemized, and it is priced the same as ballast, instead of as earth excavation. Sub-ballast should receive a lower price than ballast and should be depreciated because it finally becomes depressed into and forms a part of the earth roadbed.

Ties: A uniform service condition of 60 per cent is allowed for all wooden ties, irrespective of their age or location in tracks. The Illinois Commission believes that this carrier has reached the stage of "normal maintenance," in which the average service condition of the wooden ties would be 50 per cent instead of the 60 per cent allowed.

Ballast: An allowance of 10 per cent of the measured quantities of ballast has been made for "loose measure," which allowance is considered erroneous. Further, ballast has uniformly received a service condition of 100 per cent, whereas it should receive the depreciation to which it is subject.

Tracklaying and Surfacing: An average service condition for the portion of the system in Illinois is found to be 78.2 per cent, which is considered excessive. Tracklaying and surfacing are functions of the life of the ties and rails and largely perish with either a general tie or rail renewal. The general service condition of wooden ties was fixed at 60 per cent, and this would require that the general service condition of rails be nearly 100 per cent to give a general service condition of 78.2 per cent to tracklaying and surfacing, a condition of rails not warranted by the facts.

Crossings and Signs: All signs, regardless of character, are given a uniform service condition on each valuation section, a proceeding incompatible with actual conditions. Each class of signs, as, for example, all mile posts or all station signs, should be separately considered in fixing a percentage condition.

Wharves and Docks: Dredging is allowed a service condition of 100 per cent, when as a matter of fact it should be depreciated.

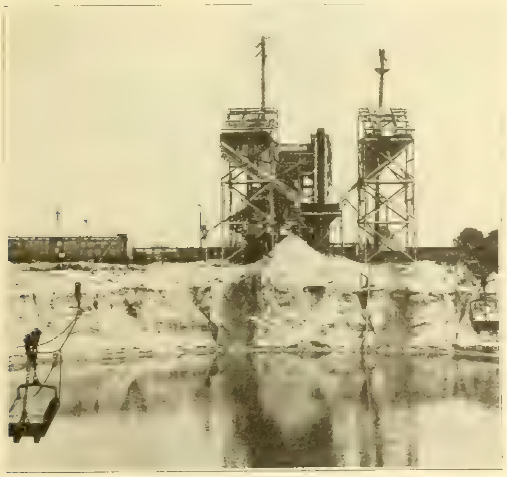
Law: The allowance for this purpose is fixed at one-half of one per cent of accounts No. 1 and Nos. 3 to 47, inclusive. It is considered preferable to ascertain the estimated cost of an organization which could properly perform the necessary legal services, because such cost will more accurately reflect the actual probable expenditures.

Interest: To the allowance of interest on equipment for a period of four months at the rate of 6 per cent per annum objection is entered on the ground that such expenditure is unnecessary and unwarranted.

GRAVEL EXCAVATORS SPOUT TO COMMON HOPPER.

The possibilities of a sand and gravel plant employing two dragline cableway excavators feeding into one set of screens are illustrated by the plant of the Granite Sand & Gravel Co., Indianapolis, Ind.

The material is dug from a wet pit, 1 cu. yd. and 1½ cu. yd., Shearer & Mayer excavators being used, operated respectively by a 75-hp. and a 90-hp. Thomas electric hoist.



Double Excavator Installation at Sand and Gravel Plant.

Originally this company operated a single excavator, and its output was doubled by adding the second machine. In the arrangement of the present plant the material, after passing through the grizzly bars, is spouted to a common hopper and carried by a belt elevator to a single set of revolving screens.

If business is dull only one excavator need be operated, and expenses are practically cut in half.

A 7,000,000-cu. yd. drainage job is being advertised for bids by R. N. Towl, District Engineer, Onawa, Ia. The work calls for constructing a main ditch 50 to 70 ft. bottom, 17 miles long, and a river improvement 75 to 100 ft. bottom, 19 miles long. It is suitable for floating, drag line and suction dredges; material is alluvial clay.

BLASTING RULES AT SANTA RITA MINES OF THE CHINO COPPER CO.

Under normal mining conditions about 1,500,000 lb. of explosives are used each year by the Chino Co. at its Santa Rita properties. To help safeguard its employes the company has posted rules, printed in English and Spanish, so that everyone, especially those that handle explosives, may become familiar with them. Some of the principal rules so posted follow:

Before exploding a blast, care should be taken to give the blasting signal and to wait until every person has reached a point of safety. Do not explode a blast until at least three minutes have elapsed from the last note of warning.

The powder "whistle off" signal must be given after each and every time of blasting.

All persons are warned not to return to the vicinity of "dobes" until at least one-half minute has elapsed from the last shot heard.

When dobying (bulldozing) is done directly in front of a shovel no one should remain on or under that shovel for protection.

In firing bank shots or toe holes the battery wires must not be connected to the battery until the person immediately in charge walks back to the battery and gives the word to connect.

Do not smoke while handling explosives, and do not handle explosives near an open light.

Do not carry loose detonators or electric detonators in the clothing. Carry them in special boxes.

Do not transport caps or cartridges containing caps to the blasting place with the supply of dynamite to be used, and do not place them side by side until ready for explosion.

Do not tamper with caps. If the caps are damaged, discard by loading into some bank hole.

Inspect the place where bulldozing has been done before work is resumed. Recover all powder and caps possible and return to their proper places.

Carelessness will not be tolerated. The careless laborer imperils not only himself but he endangers his fellow workman as well.

All blasting machines must be tested with rheostat at least twice a week. If blasting machine is defective, this must be reported. The machine must not be used until it has been repaired.

During cold weather no dynamite but the nonfreezing powder shall be used unless by order of the general foreman.

Powder boxes and powder cans must not be opened otherwise than with the wooden tools provided (which are mallet and axe handle).

Black powder cans should not be rolled down the bank.

Black powder should not be opened near a light or fire.

Dynamite must not be rolled down the banks tied to a rope except in places and manner designated by the head powder foreman.

It is absolutely prohibited to store powder or caps anywhere about a steam shovel. All such recovered material must be gathered up and returned to the boxes.

Do not allow explosives to become scattered. Immediately after each finished period of loading all unused powder and caps must be returned to their respective places.

Detonators and powder must not be stored in the same place.

Fuse, firing machines, and all tools necessary for blasting must be kept in a box separate from the powder. All material must be kept under lock and key.

Place all powder boxes so that the cartridges will rest in a level position.

Do not fasten a detonator with the teeth or by flattening with a knife; use a crimper.

Do not put two independent charges of explosives in the same drill hole.

Do not attempt to draw nor to dig out the charge in case of a misfire.

Do not explode a charge to chamber a hole and then immediately reload the hole; the hole will be hot. Water must be used to cool it.

No person shall blast a hole alone; he must have some one near him.

For dobying, fuse must not be less than 30 inches; for springing holes not less than 18 inches.

All electric detonators must be tested with galvanometer before placing stemming in the hole.

Not more than three men are to load a hole at one time.

In loading bank holes one primer must be placed in the hole before adding any of the charge of powder.

After primer or powder has been placed in the hole no metal shall be used either to tamp or clear the hole.

All tamping used in holes shall be screened dirt.

Caps and electric detonators shall be stored in separate box, which shall be marked "Cap Box." Nothing else shall be stored in these boxes.

One man is never to trim a bank alone; at least two men should work together.

While trimming, bank men are not to go down the bank unless with a rope securely fastened above.

SHRINKAGE IN FILLS.

One of the questions considered by the Committee on Roadway of the American Railway Engineering Association in its 1917 report was the allowance for shrinkage in fills. To obtain information on this subject the following question was sent to railway officials and railway contractors: What allowance for shrinkage, both in width and height, have you found satisfactory for different heights of fill and different materials, first, on new locations, and, second, under traffic? The results of the inquiry are given in the February Bulletin of the Association, from which the following notes are taken. Table I is a summary of some of the replies. The conclusions of the committee were as follows:

TABLE I—SHRINKAGE IN FILLS.

Atlantic Coast Line—10% for sand-clay soils.
Chicago & Alton—15% for clay or loam deposits from trestles.
Chicago, Rock Island & Pacific—10% on new and old work.
Illinois Central—10% on new location.
Illinois Central—3% in height and 10% in width under traffic.
New York, New Haven & Hartford—10% on new location.
New York, New Haven & Hartford—3% under traffic.
Seaboard Air Line—10% for height; fills 15% wider than standard.
Rock Island Lines—About 10% is general rule.
Grand Trunk—1 in 10 for ordinary earth fill.
Grand Trunk—1 in 20 in sand or gravel.
Soo Line—Embankment with cars from trestle, ½ to 1% per foot of elevation.
David W. Flickwir*—2 ft. for each 10 ft. in height.
John F. Dolan*—10% for shrinkage.
P. McManus*—On new location: Earth, up to 15 ft., 10%; up to 30 ft., 12½%; up to 50 ft., 15%.
Paterson-Moran Co.*—7 to 10% in clay.
C. W. Lane & Co.*—10% for width or height.
C. P. Bower*—Earth, about 1½ ft. higher for 25-ft. fill.

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*Railway contractor.

In determining the allowance for shrinkage to be made in a fill, it should be remembered primarily that it is easier to add to the height of a fill that settles than to lower the track if the settlement does not amount to as much as that anticipated in the original allowance. Therefore, unless the shrinkage of a material is well-known in the conditions under which the fill is made, it is best to be well on the safe side; i. e., little or no allowance should be made in height; the extra material, when possible, being deposited where it will be conveniently available for raising the track, as required. The allowance in width should be from about 5 per cent to 20 per cent of the height of the fill, depending on the material and conditions.

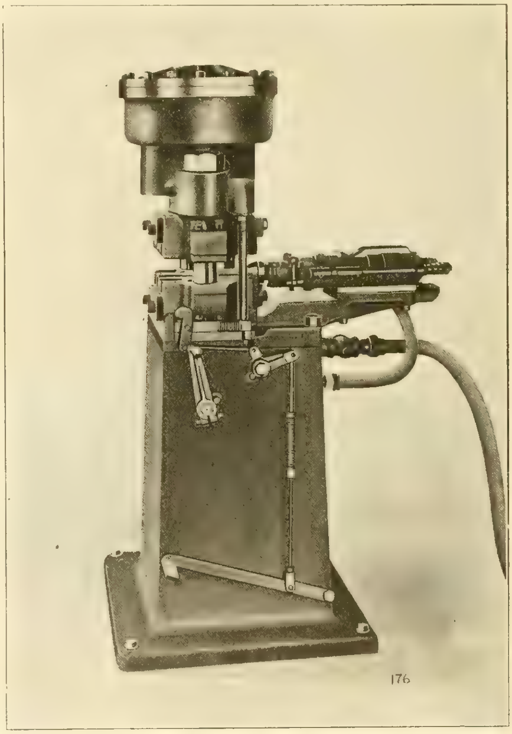
The material used for fill varies in shrinkage from sound, non-disintegrating rock, or gravel, which is least, to certain swelling clays, which give the greatest shrinkage both in compactibility and erosion at the slopes. While vegetable loam has a large percentage of actual shrinkage, it so quickly produces a protection cover of vegetation that the shrinkage due to erosion is usually small. Where frozen material must be used in making a fill, heavy settlement must be expected, and this is to be avoided where possible.

The material and contour of the ground supporting the fill is also a matter of considerable importance. This is especially so where unstable material is encountered.

The method of making the fill should also be carefully considered. When the tracks are being raised under traffic, the vertical shrinkage will be largely taken care of in the course of the work. When the fill is made by teams or such means as to reasonably tamp and compact the fill in thin layers as it is made, the same is true. Where, however, the fill is made by trestle and without puddling or other method of compacting, the settlement is apt to be considerable.

NEW DESIGN OF PNEUMATIC DRILL SHARPENER.

A new design of pneumatic drill sharpener has been developed by the Denver Rock Drill Manufacturing Co. of Denver, Colo. This is known as the Model 8 Waugh Sharpener, and consists of a pneumatic dolly hammer and swaging ram mounted on a single pedestal. The ram piston not only operates the swaging dies and steel cutter but it is also used for clamping the steel when dollying. In addition, a unique pin pulling device operated by a foot lever is attached to the side of the pedestal. The cylinder which supplies pressure to the ram piston is located directly above the die blocks. The dolly hammer is of the valveless type and uses the air expansively. This type of hammer strikes a light, but very rapid blow, which is said to be a decided advantage in working steel. All of the operations of this machine are controlled by a single lever which is so situated that the operator can easily observe the working of the steel. The dollies are returned by a constant pressure piston instead of a spring, which has the advantage of not only facilitating the changing of dollies, but also eliminates spring trouble and spring breakage. The weight of the machine is 2,400 lb. This company is also developing a smaller machine, which it expects to put on the market shortly.



Model 8 Waugh Drill Sharpener.

CONSTRUCTION METHODS FOR ROGERS PASS TUNNEL OF THE CANADIAN PACIFIC RY.

The Rogers Pass tunnel of the Canadian Pacific Ry. was completed last December, 11 months ahead of the contract time. It is a double track tunnel, slightly more than 5 miles in length. One of the most interesting features of the construction was the employment of a pioneer or auxiliary heading. The methods employed in the driving of the tunnel are described by Mr. A. C. Dennis, superintendent in charge of the work for the contractors, Foley Bros., Welch & Stewart, in a paper* presented Feb. 7 before the American Society of Civil Engineers. The paper is printed in the January Proceedings of the Society, from which the following is abstracted:

The tunnel, except for 1,200 ft. of the east end and 400 ft. of the west end, is all in solid rock, classified as quartzite in the geological reports, but consisting largely of schists.

East Pioneer Heading.—The east pioneer heading was started in September, 1913, about 50 ft. north of the main tunnel, 700 ft. west of the east portal, and about 60 ft. above the main tunnel level. This location was adopted in order to save 700 ft. of pioneer tunneling, to reduce the quantity of soft ground heading, to enable work on the heading to start sooner than that on the approach cut, and to get rid of the muck readily. The power was furnished by the temporary erection of an old compressor along the Canadian Pacific Ry. track above and a pipe line down the hill to the work. This heading was run as nearly level as drainage would permit. The grade of the main heading reached the grade of the pioneer at the third cross-cut, the two former cross-cuts being driven to the dip, and material from the main heading being hoisted up the incline. The heading reached solid rock about 600 ft. in, at which point the first inclined cross-cut was started, at about the beginning of 1914. The pioneer tunnel, in rock, was driven about 2 miles in 1½ years. The maximum progress was 776 ft. The daily average was 20 ft. for the entire drift in rock.

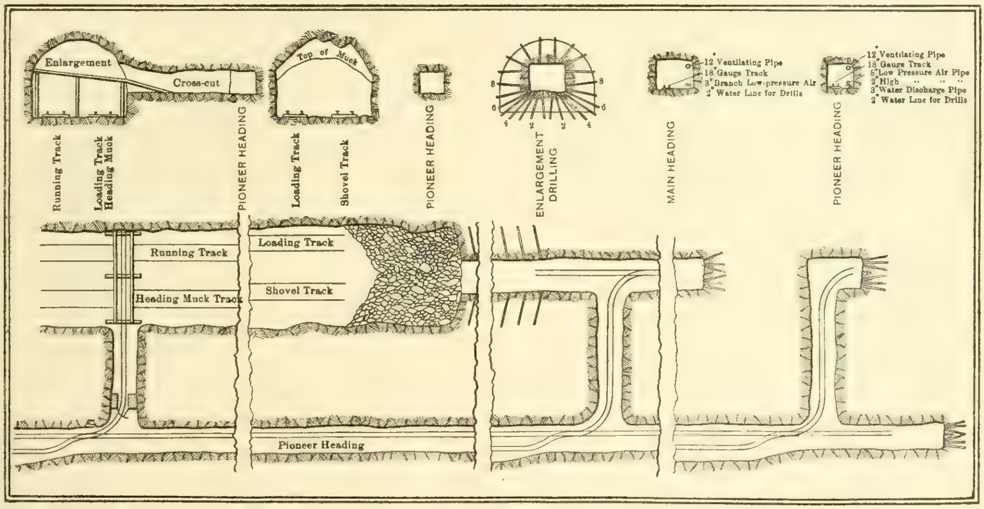


Fig. 1—Details of Pioneer Heading and Its Relation to Main Tunnel.

West Pioneer Tunnel.—The west pioneer heading was started by an incline, 300 ft. long, from the rock outcrop, 700 ft. east of the west portal, about 150 ft. above the main heading level, and 50 ft. south of the main tunnel line. This location was selected in order to provide dumping ground, shorten the length of heading to be driven, avoid soft ground tunneling, and permit an earlier beginning than by waiting for the approach cut excavation. This incline was very wet and took 2 months to drive, being finished in the latter part of July, 1914. This pioneer tunnel was driven for a length of more than 1½ miles in less than a year, the maximum monthly progress being 932 ft. The daily average of 24 ft. for nearly a year, largely through very hard quartzite is also unusual.

Pioneer Headings in General.—The pioneer tunnel, in rock, was 7 ft. high and 8 ft. wide. It was driven with light hammer drills, using hollow steel, with water attachments. Three drills, in general, but four in the hardest rock, were used in a heading. Spare drill machines, for the replacement of drills out of order, were kept conveniently at hand in the heading. No repairs were made under ground. The hammer drills are convenient and rapid, the delay and expense of their constant breakage perhaps balancing the advantage of speed under ordinary conditions. The drills are mounted on a light horizontal bar, about 18 in. below the roof line. Air and water are taken over the muck pile, or on hooks in the side, by a single hose line for each, to a manifold from which short individual hose lines supply the drills.

Light cars (½ cu. yd.) were used for muck, and the latter was taken off the track, instead of building sidings for this purpose. Shoveling plates were used at the face and on the side away from the track for some distance back of the face, in order to facilitate the handling of empty muck cars. The ventilating pipe was a 12-in. wooden water pipe connected to the Connersville blowers used for the exhaust. This pipe was hung on the side away from the track, close up to the roof, and was carried to within 20 ft. of the face. Little damage was done to this pipe by blasting. The blowers were started exhausting when the first shot was fired, or a little before, and were run for 20 min. The men got back to work in from 5 to 10 min. No compressed air was allowed to be blown out for ventilating purposes. After a round was shot, the drillers followed the smoke back, barring down the roof, bringing explosives to re-shoot, and wetting down the muck piles, sides, roof and face with water hose. The muckers cleared the track and began loading the muck which was scattered back.

When no further blasting was required, the lights were hung, the foreman sighted the line and grade point in the face, and the drilling gang set up the horizontal bar, placed their drills and proceeded. There was rarely any muck to be handled before the drilling could be started, as it was thrown back from the face by the heavy loading in the bottom holes and the fact that they were shot last, for this purpose. There were two helpers to three drills, and they brought up and changed the steel and adjusted the drill machines. When the drilling from the upper set-up was completed, the drillers took down the machines and carried them back, with the hose connections still attached, and oiled them up. After the mucking was done, the bar was dropped to the lower set-up, near the floor, and the drills were set to drill the bottom holes or lifters. The drills were carried forward, put on the bar, and were drilling sometimes in less than 2 min. after the bar was dropped. While the bottom holes were being drilled, the muckers laid the track, adjusted and covered the mucking sheets with muck, and brought up the explosives. The holes were loaded by the machine men, helpers and foremen.

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*"Construction Methods for Rogers Pass Tunnel," by A. C. Dennis. Pp. 3-27. Vol. XLIII, No. 1, Proceedings American Society of Civil Engineers.

For the small part of the tunnel where re-shooting was not necessary, an 8-hour shift could do two rounds per shift, or a little better. Two men pick down the muck, and three men load the car and push it out, while three others stand by with an empty car, ready to put it on the track and load it. The three men taking out the loaded car return near the face with an empty car, take it off the track, and rest until the load comes out. The men get a rest from the monotony of steady continuous shoveling, and the empty car is available at once after the load goes back. The pipes for ventilating, and for air and water were laid by a pipe man and helper, who looked after several headings.

Doing this work with muckers was unsatisfactory. Muck cars were taken from the heading back to a siding by a single mule, and from there to the dump by two or three-mule team driven tandem, until this method became inadequate, and then compressed-air locomotive haulage was substituted for the long haul. The heading muck cars, after the shovel and switching track had cleared a cross-cut, were taken to the cross-cut, pulled up an inclined trestle by air hoist and cable, and dumped into standard-gage cars, as shown by Fig. 1. The cross-cuts are from 1,500 to 2,000 ft. apart. Air pressure was maintained at about 90 lb. at the drills, which required 125 lb. at the compressors toward the end of the work.

The rounds were usually 6 ft. The cut holes were generally shot once or twice, and the remainder of the cut was shot with the rest of the round. All shooting in headings was done with fuse. The explosives used were 40 and 60 per cent, low-freezing gelatine, with No. 8 caps. The rock was hard to break, and the quantity of explosives was necessarily high. From 21 to 28 holes were drilled in the pioneer face. Change of shifts was made at the heading, the shift coming on taking the tools out of the hands of the shift finishing. Three shifts a day were worked every day in the year, except for one day at the east end, due to the burning of the fan house, and one day due to the breaking of the air main by a snowslide. The pioneer gang drove the cross-cuts between the pioneer and the main tunnel heading. The pioneer tunnel was not driven for the last mile, connection being made by the main heading only, which was all drilled up for enlargement before the enlargement blasting reached this section. The main heading work had to be completed before the enlargement blasting and mucking reached the last cross-cut, as it would have been impossible to maintain the air connections, or ventilate the main heading, after that time, so as to allow continuous work.

Main Heading.—The main heading was entirely through the rock section. It was 11 ft. wide and 9 ft. high, the center line being the same as that of the completed tunnel and the bottom being 6 ft. above the sub-grade. The position and size were such that lateral holes could be drilled from this heading to break the enlargement to the required dimensions. The air, water and ventilating pipes for this heading were branches from the mains laid in the pioneer heading. Access to this heading was obtained through the cross-cuts from the pioneer, and muck was handled around the enlargement operations by the pioneer route. This heading was generally driven in a westward direction, on account of the drainage. The system of driving was similar to that in the pioneer. The rounds averaged about 7 ft., and 32 holes were drilled in the hardest rock. The main heading was sometimes driven from several faces. The average daily progress per heading at the east end was slightly more than 16 ft., and the maximum monthly progress was 621 ft. The average daily progress per heading at the west end was 20 ft.; the maximum monthly progress was 762 ft.

Headings in General.—The headings were sublet at a price per foot and a bonus for more than 450 ft. per month, the sub-contractor furnishing the labor and explosives only. This arrangement proved unsatisfactory, and was discontinued in September, 1914. After this time a substantial bonus, based on the monthly footage and equated for hard rock, was given and divided among all men directly connected with the heading driving, in proportion to their regular wages earned for the month. It was agreed that the rate of bonus would not be reduced. The latter arrangement resulted in 23 per cent greater speed, and a large saving in compressed air and other items furnished to the sub-contractor under the former arrangement.

Enlargement Drilling.—The enlargement drilling, after some experimenting, was done as shown by Figs. 1 and 2. Each hole was pointed by clinometer, the column carrying the drill being set always at the same distance off the center line, and the arm for the lower and upper sets being always the same distance above the sub-grade. Line and levels were furnished by the Railway Company's engineers, and a string was stretched by which the columns and arms were located. Each drill hole has its proper distance from the arm. The drill holes were thus bottomed at a regular distance beyond the neat line of the completed excavation. The holes, being bottomed with reference to the line and grades given by the engineers, were not affected by irregularities in the heading driving. The columns were set by men for that purpose, so that the drillers and helpers had only to do the drilling. The drill steel was brought to the drillers, and the dull steel was taken away. The drillers and helpers were paid their wages in any event, but the footage for each man was kept, and if the price set per foot drilled amounted to more than his wages, he was given the difference as a bonus check. Air and water connections were made for every third ring of holes, and only one drill machine, though handled by each runner of the three daily shifts, completed the three rings, and then moved to the head of the line, taking the next three rings. Congestion of men and material was thus avoided, and each man had a fair chance to work on an equal quantity of hard and soft rock.

There was extreme variation in the quantity drilled by different men in different rock. The same man might do only 6 ft. a shift in the hardest quartzite, and more than 100 ft. per shift in the softer schist. New men, after a month's practice, generally made more footage than men of long experience in mining. In general, it was found better to train green men than to try to get men accustomed to piston drills to learn to run hammer drills.

Most of the rings were 6 to 6½ ft. apart. When explosives rose in price it was found economical to space the rings 5 ft. apart, as the extra drilling cost was balanced by the saving in explosives, with the added advantage that the muck was broken into smaller pieces and scattered farther back. Where the roof was soft and full of slips, so that trouble was anticipated, the upper set of arms on the column was lowered 1 ft., in order to leave some trimming of the roof to be done by jack-hammer, flat holes and light blasting. The air and water for the enlargement drilling, as well as the supplies, came by the pioneer tunnel and the cross-cuts, so that this drilling was not disturbed by the enlargement blasting. The drilling for the last mile, where no pioneer tunnel was driven, was started at the middle and progressed toward the portal, the track, pipe, etc., being removed as the drilling was finished.

The stopping of the pioneer tunnel was well-timed, as the main heading was driven and the enlargement drilling completed just in time to avoid delaying the enlargement blasting and mucking at the east end.

Enlargement Blasting.—There was considerable difficulty in breaking the bottom to sub-grade when the rock excavation was first started. This was overcome by dropping the floor of the main heading 1 ft. and drilling the holes in the bottom 1 ft. deeper. Difficulty was found also in getting the sides below the springing line to break for the full width. This was overcome by drilling one or two relief holes at this locality in tough breaking rock. In tough rock, two, four, six and sometimes eight holes were sprung. (Fig. 1.) If over-sprung, the ring being shot was likely to break into the next ring and explode it, or shake it up so as to spoil the effect of the blast.

Generally from 10 to 15 rings were kept loaded ahead. Any part of a hole which had not broken, and could be found, was reloaded and shot with the next ring. Generally a little muck was left in the face by the power shovel in order to prevent the first ring from scattering back too far. If the previously shot material had not broken to the required width, however, all the muck was loaded, and jack-hammers were used a drill up this tight rock, after which it was shot before the regular rings were blasted. Several bottom rings were first blasted, then a top and bottom ring were blasted together until the muck piled up to within 4 or 5 ft. of the roof. Then blasting was discontinued, and the men scaled and trimmed the roof, working from the muck pile. Where no holes had to be reloaded, rings could be blasted at intervals of from 15 to 20 min. The blasting was done with a battery in the main heading, and the bottom holes were all loaded ahead, the wires being wound up and stuck in the holes, from which they could readily be pulled out and connected. The upper holes were loaded, but no primers were put in until ready to blast. The holes were loaded to within 4 ft. of the collar, whether sprung or otherwise.

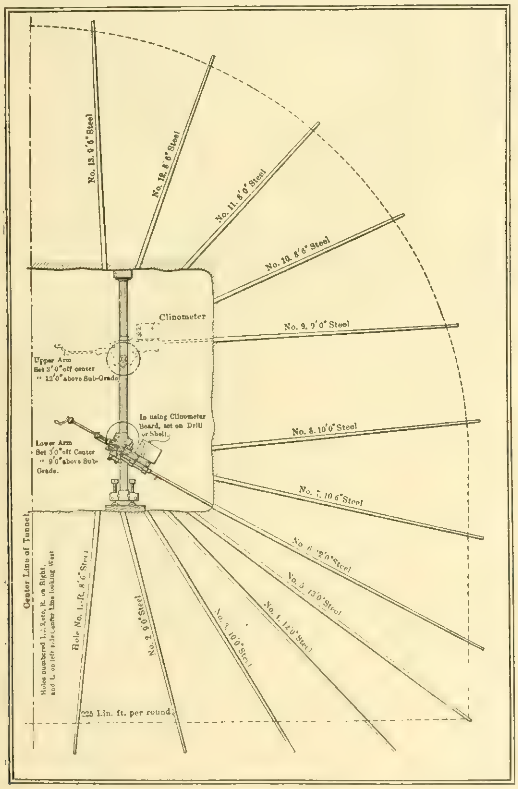


Fig. 2—Half Section of Main Tunnel and Center Heading, Showing Column and Drill Setting for Ring Drilling.

When retiring in the main heading to blast, the blasting gang took back the scaling tools, so that they might examine and scale the roof of the heading if necessary as they returned. After several rings had been blasted, the power shovel crew commenced to clean up the beginning of the muck heap, and only retired a few minutes for the following blasts. Several top rings were generally held and shot at meal times, when the shovel had excavated sufficient muck to provide room for more without blocking the airway and manway over the pile.

The smoke and gas from the blasting were quickly taken out by the fresh air forced into the pioneer tunnel by a "Sirocco fan" at the portal. The air circulated through the pioneer tunnel and the cross-cut ahead of the blasting, and then back through the main heading, over the muck pile, and out at the portal of the main tunnel. This circulation was prevented from short circuiting by stoppings and doors in the cross-cuts passed by the shovel. The quantity possible to shoot depended on the distance the muck was thrown back, or the quantity of muck for which there was room without interfering with the scaling and trimming of the roof; it varied from 24 to 110 ft. Much time was lost in taking up the track before blasting, in cleaning up the thinly scattered muck directly after a blast, and by other delays incidental to each clean up, which it made desirable to shoot as many rings as possible.

Enlargement of Mucking.—Mucking was done with small steam shovels, with cylinders enlarged so as to be efficient at 100 lb. air pressure, and with the boom sheaves set back so as to shorten the booms and protect the sheaves. The shovels loaded the muck into 12-yd., standard-gage, air-dump cars. The cars were shifted to the shovel by two small compressed-air locomotives, and were taken from a spur near the shovel to the portal by a larger compressed-air locomotive; they were taken by a steam locomotive from the portal to the dump. During the past year the shovels mucked 18,550 ft. throughout 3½ miles of tunnel, or more than 2 ft. per hour. Blasting and trimming took about one-quarter of the time. The best monthly run for one shovel was 946 ft. at the east end, and 1,030 ft. at the west end. The ground between the third and fourth cross-cuts at the west end became so dangerous, owing to the material in the roof and sides falling, that one shift out of three had to be devoted to scaling this section until it was concreted. About 2,500 cu. yd. fell or was scaled in this section, on account of the disintegration of the material on exposure to the air. The scaling car throughout the work was handled by the air locomotive, and the scaling was done by the shovel crew or others during the time the shovel was stopped for enlargement blasting. Any rock not broken to the required dimensions was drilled off the muck pile, or from the floor, as the shovel cleaned up as far as possible, or from a car left at the shovel crew's meal time, and shot before the next rings were blasted. The enlargement drill holes were the general guide as to the trimming required, such points as were missed being marked by the Railway Company's engineer. There was very little over-breakage.

Concreting.—About 1½ miles of the tunnel, including the soft ground at each end, required concreting. This work was sublet to the Bates & Rogers Construction Co. of Chicago and Spokane. The concrete section is heavily reinforced, which prevented the use of the pneumatic method of placing. The sub-contractors used wooden forms, and deposited the concrete from a platform near the roof reached by an inclined trestle. The concrete mixer was on a car, and the materials were on other cars back of it. The concrete from the mixer flowed into a small car which was hauled by cable up the trestle incline to the high platform, from which it was shoveled into the forms. Much of the lining required back as well as front forms, and the space behind the back forms was filled with rock or wood. This back form and back-filling work was slow and expensive, especially where there were only a few inches between the back forms and the rock.

Engineering work is under way and it is expected that contracts will be let the latter part of the summer for the enlargement of the Scioto River channel for Columbus, O. This project calls for an expenditure of approximately $3,500,000. The improvement was authorized by popular vote at the November election.

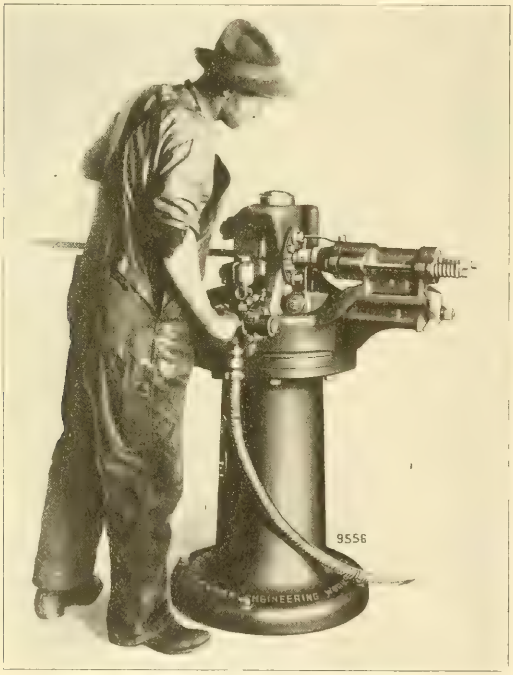
A LEYNER SHARPENER FOR SMALL SIZE DRILL STEEL.

A drill sharpener designed especially to meet the requirements of the small mine, quarry or contract has been placed on the market by the Ingersoll-Rand Co., New York. The machine is known as the Leyner jacksteel sharpener. It is a small edition, with modifications, of the standard No. 5 Leyner sharpener.

The new machine is designed to handle the small sizes of steel, such as used with jackhamers, stopehamers, plug drills of various kinds and the like. The manufacturer limits its capacity as follows:

Steel sizes: 1⅛ maximum diameter round, cruciform, and light section twisted or banded steel; 1-in. maximum diameter hexagon or octagon steel; ⅞-in. maximum diameter square steel.

Bit sizes: 2-in. maximum diameter 4, 5, 6, point, Z, X and single or double chisel bits of standard 14-degree taper; 1⅞-in. maximum diameter "Carr" or bits of other than 14-degree taper.



Leyner Sharpener for Small Size Drills.

Shanks can also be made on the smaller sizes of steel by the usual Leyner method.

The Leyner jacksteel sharpener is of simplified design and extremely compact. Its weight, 925 lb., permits ready transportation when desired. No foundation is required other than a planking support about 3½ ft. square.

An unusual feature is the employment of a single piston rod on the clamping piston. This allows the Leyner die and dollying hammer to be so located as to operate immediately under the eye of the operator. This advantage of complete visibility of the entire operation is stated to be of prime importance in securing the best possible grade of work.

An entirely enclosing die is employed, as with the large Leyner sharpener, in which the metal of the bit is thoroughly compacted by the dollying hammer. The completion of the sharpening operation within the die effects the same absolute correctness of gage and exact duplication of bits of any gage. A single lever (under the operator's hand in the cut) controls both clamping and dollying. This, it is claimed, conserves the muscular effort as well as the time of the operator.

The Leyner jacksteel sharpener is 4 ft. high, 3 ft. long and 2 ft. 4 in. wide, and operates on compressed air.

SOME PROBLEMS OF AN ENGINEER IN PUBLIC SERVICE.

Some of the unusual difficulties that face an engineer in getting into the public service either as a city or state official were discussed by Mr. Charles J. Bennett, State Highway Commissioner of Connecticut, in a paper presented at the annual meeting of the Connecticut Society of Civil Engineers. The paper, practically in full, follows:

It had previously been my impression, before taking public office, that an engineer was qualified to handle public problems of any character and should be, by nature of his training, the best equipped, professionally, to administer public work as an executive. After some years in this class of work, I am forced to admit that there is more to the proposition than a mere engineering training; that is, there is need of something in addition, in the training of a public official, than the mere ability to solve engineering problems and to deal with the actual construction or maintenance of engineering structures or devices.

It is my purpose, therefore, to indicate some of the points where engineers are lacking in information, and then to present some of the peculiar features to which these deficiencies apply.

The young engineer, as a rule, deals too much with the small unit of measure. His preliminary training in cost-keeping has to do particularly with small units, and his endeavor has been to reduce the cost of the unit without particular regard to the total number of units or the entire cost of the work to be done. In other words, the engineer, as a rule, has very little concern for the total sum to be spent on a particular job. I make this statement with some hesitancy, but with considerable proof from past experience. Most of the young engineers with whom I have come in contact, including myself, have in view the completed construction of a piece of work without particular regard to its financial return, and have subdivided this work into small units, and endeavor to get as low a cost as possible for each of these units, losing sight, usually, of the cost of the entire project. This fault arises particularly from the training of the engineer being mainly in the physical part of the construction. Few engineers have any training in commercial matters, and it is rare indeed to find a young engineer who has any conception of the necessity of keeping a set of books covering the appropriations or the construction items under his charge. A particular piece of work is undertaken, and the engineer desires only to see this work well done and to present his monthly estimates at the proper time to secure a payment, whether the work be force account or contract. If engineers are required to work through a budget, they are immediately forced to see the need of keeping track of their work before it is undertaken; that is to say, design the work so that it will meet the sum of money to be expended and to determine from time to time that the cost is going to be within specified limits.

Many times in an engineer's experience he is brought into contact with the law; that is, all public works officials must work in accordance with laws or ordinances. Engineers, as a rule, are fairly well equipped with a knowledge of contract law, but have very little training in common law or any law which has to do with particular localities. Consequently, the engineer and lawyer come to a disagreement from time to time, due to the engineer's lack of information, and also, I am frank to say, to the lack of appreciation on the part of the lawyer for the engineering profession. This country is governed by lawyers and not by engineers. Consequently, there is need for a closer knowledge of law on the part of the engineers, and to convince the lawyer that engineering is a profession of itself, entirely separate from the legal profession and with fully as much knowledge required to master it.

Another difficulty with which the engineer has to contend is the fact that there are so many "experts" in engineering matters who have absolutely no engineering knowledge. No matter what structure an engineer may design, he may rest assured that there will be a hundred experts among his clientele who will consider themselves qualified to criticise his selection of design and the method of carrying it out.

One of the greatest difficulties with which the public official has to contend is the interference from people who know a great deal about engineering matters from reading superficial articles in the newspapers. For instance, in the selection of road surfaces, there has been unlimited advertising by commercial interests of particular types of road surfaces. Some prominent political official reads the Saturday Evening Post or the Ladies' Home Journal and finds advertised in either or both of these periodicals a universal panacea for road ailments. He immediately prepares to influence the engineer to secure this surface for roads in his vicinity. Again, in the construction of a bridge, the engineer prepares a design for a bridge which will be satisfactory for the loading and location, fulfilling all other requirements of the situation. A local representative desires some other kind of a bridge, regardless of what the engineering problem may be. Some one immediately sets himself up as a bridge expert and informs the engineer who designs the structure of what is necessary, and practically forces a different design than the most efficient one.

Such examples as the above are innumerable in the public service. The outside influence, even eliminating that which is improperly or unfairly presented and requires no attention, is one of the greatest hindrances in securing the proper solutions of engineering problems in connection with public service; and until the public realizes that engineering is fully as much a profession as medicine or law it will be extremely difficult for us to progress along the right lines. In brief, engineering matters should be left to engineers, and they should be trusted to solve special problems without outside interference, either selfish or not.

I am conscious that in outlining these difficulties I am stating facts that are known to all of us engineers. It is extremely difficult to give a remedy for the situation of which we complain. Some of the failures of the engineers themselves have been noted, and some of the difficulties with which they are faced are also stated.

I am inclined to think, with many of the engineering periodicals throughout the country, that the engineering societies take too little interest in matters with which their members are frequently concerned. One finds in connection with legislative matters that the Bar Association or the Medical Association follows very closely in legislation which affects their profession. Apparently the engineering societies have taken few steps to see that unfavorable legislation is killed.

Furthermore, from time to time certain engineering mistakes are mentioned in the engineering periodicals, but very little, if any, action is taken by the engineering associations to investigate for the general benefit of the profession. I have considerable pride in being an engineer, and wish to see the engineering profession take its proper place in the scheme of national life; yet until some concerted action is taken by societies or associations such as these we shall be still in the same position as heretofore.

As an indication of what an engineer may do, there is one engineer in the present Connecticut legislature who is showing himself to be invaluable in connection with the work being done by that body. A systematic investigation of all measures which concern his committee is carried out, and the results, I am sure, will be good.

If associations and societies, such as our own, will take an active part in legislation and in investigation of engineering matters, especially mistakes, we shall have taken a step toward the placing of the engineering profession on its proper plane.

I began this paper with an idea of stating some of the unusual problems which come to an engineer in public service. Without being too specific in examples, the engineer in charge of an administrative office, such as is held by many of us at the present time, has very little to do with engineering matters. The technical details are easily solved by engineers employed by the department or by consulting engineers used from time to time on special problems. The administrative end of the work has to do more with the business side of public affairs, and the engineer may carry his studies as far as he pleases with benefit both to himself and the general public.

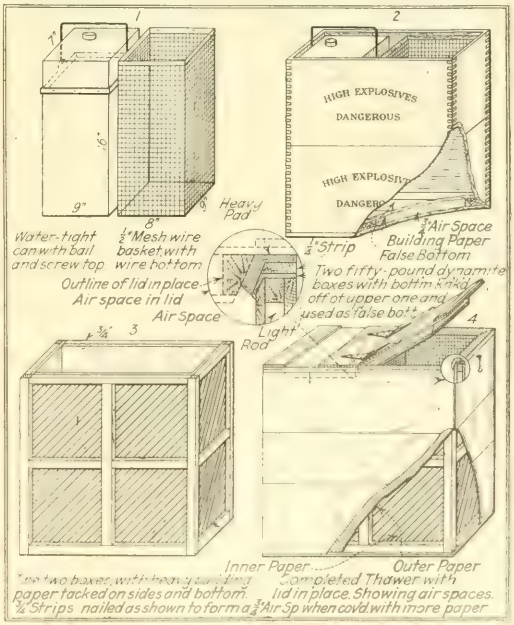
If some of the deficiencies mentioned in the first part of this paper are overcome, engineers will be better prepared for the discussion of taxation subjects, valuation of land, economic return from constructions of different characters and the necessity for undertaking large projects for the general welfare of the public.

Every large problem should be considered from as many different sides as it is possible to view it, and after the problem is solved to the apparent satisfaction of the designer it should be examined again to see if there is not some entirely different solution which may be found. For instance, I have in mind an elimination of grade crossing proposition where several streets crossed the railroad tracks, and the original plan called for a straight elimination of all crossings. I was later found that consolidating several streets, relocating the tracks, tearing down and rebuilding certain properties gave a very much more beneficial solution, which was only reached through a knowledge not only of the engineering features involved, but of the economic side of the question.

The engineering profession may be as big as we care to make it. There is no limit to the size of the problems to be solved or the magnitude of the position that engineers may hold, not because they are engineers, but because they apply their engineering knowledge in a broad mind and in a far-seeing way.

HOME-MADE DYNAMITE THAWER.

The dynamite thawer shown in the accompanying illustration was designed by the Department of Agricultural Engineering of the University of Wisconsin. It is intended primarily for the use of farmers employing dynamite in grubbing and clearing their farm lands. The heating agent is a can of warm water set inside a double walled box made from two 50-lb. dynamite boxes. The insulation is obtained by a ¾-in. air space on the sides, top


1
2
1"
16"
9"
8"
9"
HIGH EXPLOSIVES
DANGEROUS
HIGH EXPLOSIV
DANGERO
Heavy Pad
Water-tight can with bail and screw top
½" Mesh wire basket, with wire bottom
¼" Strip
¾" Air Space
Building Paper
False Bottom
Two fifty-pound dynamite boxes with bottm knkd off of upper one and used as false bott
Outline of lid in place
Air space in lid
Air Space
Light Rod
¾"
3
4
Inner Paper
Outer Paper
The two boxes, with heavy building paper tacked on sides and bottom. ¾" Strips nailed as shown to form a ¾" Air Sp when covd. with more paper
Completed Thawer with lid in place. Showing air spaces.

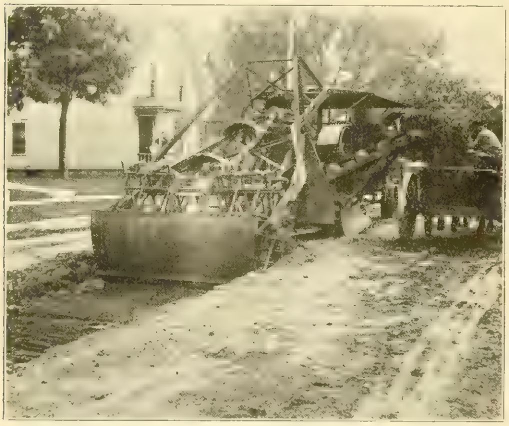
Home Made Hot Water Dynamite Thawer.

and bottom. A wire cage holds the dynamite and does not allow it to touch either the wood or the can. One can of warm water will thaw 30 or 40 lbs. of dynamite and keep it soft for 24 hours.

GRADING MACHINE FOR PAVING AND ELECTRIC RAILWAY TRACK WORK.

The General Engineering & Construction Co. of Rockford, Ill., sub-contractors for municipal street work, has perfected an interesting type of grading machine for use on certain conditions of street excavation.

This machine is stated to be particularly adapted to grading in connection with street paving work, especially where it is desirable or necessary to haul the dirt in dump wagons and where space is limited as in many points. It is also adapted to excavating trench for street railway tracks. It cuts a strip 8½ ft. wide, and will excavate 2 or 3 in. deep, or as deep as 5½ ft., the cutting wheel working on a boom being instantly adjustable by a screw raising or lowering. An indicator is provided so that the operator can run true to a grade line. The earth is deposited in dump wagons and the production is claimed to be so uniform that the number of teams each day can be properly proportioned to the length of haul so that there will not be over half a minute lost team time at the machine on each trip.



Street Grading Machine Used by General Engineering & Construction Company.

This machine can be run so as to cut very close to a finished fine grade, saving a considerable amount of expensive hand work. In practice, it is found best to make the outside cuts on street work first, cutting to a line to allow room for the curb and gutter and the forms. On the outside cuts the excavator is pitched to conform to the crown of the street. If the width of the excavation should be 25½ ft., there would be two outside cuts, one cut in the center with nothing left, and the third and middle cut made flat. If the width of the excavation was less than 25½ ft. the result would be the same.

If the width of the excavation was 27½ ft. wide, for instance, there would apparently be 2 ft. of the side which could not be handled through the machine. However, this extra material is taken care of by making the center cut as before, and sufficiently deep so that the 1 ft. of surplus material on each side of this cut can be leveled down and rolled into the center cut.

In practice it has been found desirable to cut slightly below the finished subgrade, and at the last cut to finish the fine grade at once by dumping sufficient material from the wagons to level it up to the desired grade and roll at once.

Material at alley intersections is taken care of by excavating deeper in front of the intersection for 16 to 24-ft. width, and plowing the intersection and slipping the earth into the extra depth.

In street railway track excavation, the track trench is usually 18 to 20 in. deep and 8½ ft. wide. This cut is made in one operation and the spoil put in wagons. If it is railway track work, the track may be removed closely ahead of the machine by jacks, and the trench being completed new track can be laid directly in back of the machine, so that in case of single track work the cars can be kept running with only a break and transfer of 150 to 200 ft. It is stated that about 500 lin. ft. of track trench can be handled per 10-hour day.

These machines have been run on both paving and street railway work in Illinois in 1914 and 1915.

REDUCING TRENCH DIGGING HAZARDS.

Many of the accidents to workmen engaged in trench excavation occur on the small jobs where there is little inspection and the men in charge are lax in the application of safety principles. The dangers involved in connection with these smaller operations are described in March Travelers Standard, issued by the Engineering and Inspection division of the Travelers Insurance Co., from which the following notes are taken:

As streets are extended or new property developed, the main systems for water, gas and sewage must also be extended. The topography of the ground may be such that a trench 6 ft. deep will be down far enough to reach the main in one section, while a block or two away a trench may be needed 12 or 15 ft. deep. Moreover, the composition of the ground may change radically as the excavations go farther down, so that the deeper trench may be far more dangerous than the mere increase of depth would indicate.

In making water and sewer connections between a house on the high side of a street, and the main water and sewer pipes in the street, the water pipes must be laid below the frost line, to prevent freezing. In order to completely drain the cellar the connection to the sewer pipe must be located at the lowest point in the cellar, and yet at the same time it must be higher than any point that the pipe passes on the way to the street and the main system. Assuming that the basement floor is 6 ft. below the ground level, it is evident that the trench must be at least 6 ft. deep at this point, and that it must incline downward as the street is approached. The nature of the soil may be such that there is no danger to the workmen in a trench 4 or 5 ft. deep without side bracing, but in one 7 or 8 ft. deep the danger of a cave-in may be well worth consideration.

This danger is increased by the fact that the significance of the change in depth or in the character of the soil is often overlooked by the workmen, who, as a rule, are recruited from the cheapest class of labor. They are directed to dig the trench so many feet deep, and are usually warned to guard against a cave-in, but often are not provided with the means or the instruction necessary to safeguard themselves. This is particularly true when the work is being done by a small contractor or builder, whose operations are not of sufficient magnitude to warrant the expense of employing a competent foreman, and who therefore tries to supervise all the work himself, by going from one job to another. Such a system is quite likely to lead to serious results, through lack of competent supervision at a critical time.

For side bracing in trenches of this kind a supply of 2-inch planks and "four-by-four" stringers, as well as jacks, saws, hammers, axes and other necessary tools, should be provided when the trenches are over 4 ft. deep, even if the ground is good; and when the ground is soft and treacherous this material should be provided for side bracing in even shallower trenches. The planks, placed in an upright position and spaced at intervals varying from actual contact up to 3 ft. apart (according to the depth of the trench and the nature of the ground), and properly braced with the four-by-four cross-pieces, will protect the workmen from cave-ins. There are many cases where the plank sheathing must be continuous, in order to prevent sandy or other uncertain soil from sliding or falling into the trench. In this case two or more stringers should be laid along the sheathing in a horizontal position, with the struts or cross-braces resting against the stringers.

It is essential for the man who places the timbers to have some knowledge of the side thrust of the ground, so that he may allow a reasonable factor of safety in determining the size of the timber to be used and the closeness of the bracing. A trench that is timbered properly is not likely to collapse, and, even though the earth pressure is too great for the timbers to withstand, the workmen will almost invariably receive sufficient warning of the state of affairs by the bulging or cracking of the sheathing, or by other unmistakable signs. If exit ladders are kept fairly close to the work, so that the men can readily reach the surface, the danger is still further reduced.

It is seldom economical to employ a windlass or a power hoist for removing the loosened earth from small, shallow trenches. In trenches not more than 5 ft. deep, for example, the workmen can throw out the earth directly from the bottom, unless the soil is very heavy; but when trenches of greater depth are needed the removal of the earth by a single handling is either hazardous, unduly laborious or physically impossible. When digging trenches more than 5 ft. deep it is therefore customary (unless power hoists are used) to construct one or more platforms, so that the earth can be passed up to the surface in successive stages. An alternative plan, favored by some contractors, consists in terracing the sides of the trench, so as to leave shelf-like areas that serve the same purpose as the platforms.

When platforms at several different heights are used they should not be placed one above another on opposite sides of the trench, because if this plan is adopted there is danger of stones or large lumps of earth rolling over the edge of a platform and striking the man below. It is far better to arrange the successive platforms like the steps of a stairway having its length running in the same direction as the trench.

All material removed from the trench should be thrown well back from the opening, so that the ground will be free for a distance of 2 ft. or so from the edge of the excavation; and the slope of the piles of material should not be unreasonably deep. These two points are exceedingly important, because neglect of either of them will be likely to be followed by the rolling or sliding of masses of earth or rock back into the trench, and the consequent injury of the men.

If the contractor provides proper tools and a good supply of timber, and sees to it that at least one of the workmen understands the importance of safe methods and knows what precautions should be taken, the hazards of trench digging can be greatly reduced, and most of the accidents that now occur can be easily avoided.

Alaskan Timber for Mine Props.—Tests conducted by the Forest Products Laboratory at Madison, Wis., indicate that mine timbers of white spruce, Sitka spruce, white birch, and western hemlock grown on the Chugach National Forest, Alaska, are fully as good as Douglas fir from the Rocky Mountain region and are superior to other Rocky Mountain species for use as mine timbers. Tests made to determine the suitability of the Alaskan trees for mine timbers showed that in bending strength developed the four species named are from 20 per cent to more than 100 per cent stronger than lodgepole pine, alpine fir, Engelmann spruce, bristle-cone pine, and western yellow pine from the Rocky Mountain region. All of these species are widely used for mine timbers and were tested by the laboratory. Sitka spruce, white birch and western hemlock from Alaska proved to be considerably higher in average strength than Rocky Mountain Douglas fir. White spruce averaged nearly as well.

A 10 CU. YD. DREDGE BUCKET.

An extra large clam-shell dredge bucket has been sold recently by the G. H. Williams Co., Erie, Pa. The bucket has a maximum capacity of 10 cu. yd. and weighs approximately 25,000 lb. The illustration gives some idea of the size.

The main hinge pin is a steel forging turned to 9-in. diameter; corner pins and sheave pins are 6-in. diameter. The high carbon steel lips are 1½ in. thick, the scoop plates being 1¼ in. thick.

A bucket of this type of 5 yd. capacity is stated to have dug 167,000 cu. yd. of clay in the month of October at Beardstown, Ill., on the levee project contract of the Edw. Gillen Dock, Dredge & Construction Co. This bucket also dug 135,000 yd. of clay in 18 working days, and in another month dug 157,000 yd. of clay. At one load the bucket picked up three tree stumps, together with a load of earth and clay, estimated to be in excess of 30 tons weight.

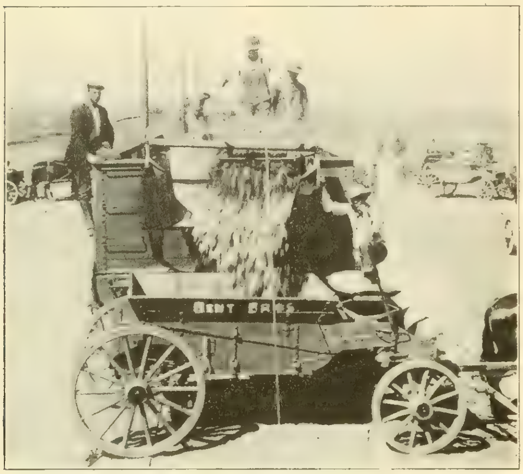
A 10 Cu. Yd. Williams Special Dredging Bucket.

The cables used to operate the 5-yd. bucket were 1½ in. for the hold line, which is equipped with a burden block, the main weight being lifted with two parts line. The closing line was 1¼ in. on the straight lift, the drums being so arranged that one operated at twice the rope speed of the other.

Slopes for High Rock Cuts.—The Committee on Roadway of the American Railway Engineering Association in its 1917 report recommends that new rock cuts 40 ft. or more in height be constructed at slopes of one-quarter to one. This recommendation is based on 65 replies received to a list of questions sent to 225 railroads. It was found that the general practice called for the slope given above for rock cuts in new construction. In disintegrated rock or shale or in cuts where stone and shale strata alternate, the report states that the slopes must be determined by the nature of the material and each individual case considered on its merits. The committee found that a number of roads were using a cement gun on cuts where the rock had been badly shattered in construction and where the strata was very much inclined to be horizontal and seamy.

A METHOD OF UNLOADING 160 TONS OF CRUSHED ROCK PER DAY.

An economical method of handling crushed rock from cars to wagons, when conditions will permit, is illustrated. This arrangement is used by Bent Brothers, engineering contractors, Los Angeles, Cal. It consists of a shut-in chute hooked on the end of the cars that the wagon can drive under. The material is scraped from the car into the wagon through the chute by means of slip scraper with a cable 70 ft. long attached so it will run over a roller on the chute; then down through a shieve wheel fastened to the rail far enough ahead so that team can be driven under same. From this shieve the slip can be pulled with a team. By this means of unloading rock it has been possible to unload about 4 cars (160 tons) per day with one team and driver pulling slip, one man holding slip and two men cleaning out ends of car.



Stripping and Loading Gravel With Auto Crane.

AUTO CRANE FOR STRIPPING AND LOADING GRAVEL.

For mining gravel and loading direct into gondola cars from pit alongside railroad siding, the Wabash Sand & Gravel Co., Terre Haute, Ind., is using a Byers Auto-Crane equipped with ½-yd. clamshell bucket.

The auto-crane was first used to strip off the overburden and has since excavated and loaded the gravel.

Stripping and Loading Gravel with Auto Crane.

As this is probably the first attempt to utilize one of these machines for their particular purpose it is interesting to know that L. R. Witty, general manager of the gravel company, says they expect to dig and load 350 yards per day with an operating crew of three men. These figures are speculative, as car shortage has prevented the machine from getting in a full day's run.

NEWS LETTERS.

St. Louis Items.

Thos. H. Joyce, of Cameron, Joyce & Co., passed through here the other day on his way back home to Keokuk from Hot Springs. Mr. Joyce reports his firm being awarded the contract for a cut-off on the Santa Fe R. R. near Washington, Kans.

The Alton, Jacksonville & Peoria Electric Ry. is going to reballast and put in a lot of new ties on its line between Alton and Jerseyville, Ill. E. E. Downes, Alton, Ill., is general manager.

P. J. Murphy is filling a trestle on the Wabash R. R. near Evona, Mo. About 40,000 yards in this job.

Charles F. Bartson, of Bartson & Millard, is spending a few days with his family at Peoria, Ill. Bartson says they will finish their levee job at Ancell, Mo., about the 15th of May.

George Harrington, of Harrington Bros., returned from Miami, Fla. George says playing with alligators and crocodiles is great sport. The Harrington Bros. secured another nice grading job in the souethwestern part of the city the other day.

Pat Hickey is spending a few days with us. Expects to return to his work in South Carolina next week. Everything going along nicely over that way.

The Missouri Valley Construction Co. of St. Louis. Mo., were awarded the contract by the city of St. Louis for constructing several wing dams at the city water works near the Chain of Rocks.

T. J. Dolan, the hustling Chicago supply man, came down this way last week and "copped" several nice orders. There is always something doing when Dolan comes to town.

The Railway Tie Co. acquired four acres in South St. Louis as a site for a rolling mill that will employ 300 men. This company is capitalized at $1,500,000 and has offices in Chicago and Philadelphia. Has leased office room in the Boatmen's building and will make St. Louis its headquarters.

A. B. KOENIG.

PERSONALS.

O. J. De Spain, county engineer of Adams County, Washington, has been appointed city engineer of Ritzville, Wash.

I. F. Waterman of Eau Claire, Wis., has been elected superintendent of roads of Volusia County Florida, with office at Deland, Fla.

Charles W. Martin, Assoc. M. Am. Soc., C. E., for the past seven years connected with the bridge department of the city of St. Louis, has become a member of the Woermann Construction Co., Century Bldg., St. Louis, Mo.

J. R. Wemlinger, C. E., president Wemlinger Steel Piling Co., and secretary American Society of Engineering Contractors, has been appointed to the rank of first lieutenant in the Engineer Office's Reserve Corps of the United States army.

G. L. Craig and L. C. Curtiss have organized the Craig-Curtiss Co. and will engage in a general contracting business at Cleveland, O. Mr. Craig formerly was with John Gill & Sons, contractors, Cleveland, and Mr. Curtiss was with McKim, Mead & White, architects, New York.

H. C. Corns, M. Am. So., C. E., and C. C. Thomas, C. E., have incorporated as the Corns-Thomas Engineering & Contracting Co., with offices in the First National Bank building, Huntington, W. Va. They will operate over a wide area as civil, consulting and sales engineers and in a general contracting capacity.

M. D. Gates has resigned as chief engineer of the B. C. G. & A. R. R. to form a partnership with C. E. De Leuw, former assistant engineer for Ewing & Allen, Chicago. The new firm will be known as Gates & De Leuw, with offices in the Monadnock Block, Chicago, and will specialize in municipal and drainage engineering.

Walter H. Braun, Joseph H. Fleming and E. P. Knollman have formed the firm of Braun, Fleming & Knollman, and will engage in a designing and civil engineering practice with offices at 233 South High St., Columbus, O. Mr. Braun was connected with the Franklin County, Ohio, surveyor's office for the last 28 years and during the greater part of this time he was engineer in charge of bridges. He served as county surveyor from 1902 to 1909. Mr. Fleming is a graduate in civil engineering of Ohio State University. He has had one year's experience in mining engineering and three years experience in the bridge department of the Franklin County surveyor's office. Mr. Knollman is a graduate civil engineer of the Ohio State University and has had five years experience in bridge work. For 18 months he was employed by the Mt. Vernon Bridge Co., Mt. Vernon, O., making and checking shop drawings for structural steel bridge and building work. After leaving the employ of the Mt. Vernon Bridge Co. and up to Feb. 1, 1917, he was employed in the bridge department of the Franklin County surveyor's office.

OBITUARIES.

Peter Siems, founder of the Siems-Carey Co., railroad contractors, St. Paul, Minn., died March 3 at Daytona, Fla., aged 75. Mr. Siems began railroad contracting in 1884 with D. C. Shepherd & Co. The firm later became Shepherd, Siems & Co. The company was reorganized in 1908 as Siems & Co., Mr. Siems sons becoming partners. Mr. Siems retired in 1910 and Mr. F. W. Carey became identified with the company. The Siems-Carey Co. at present has the contract for building some 1,200 miles of railway in China.

INDUSTRIAL NOTES.

The Duplex Truck Co., Lansing, Mich., is about to start the erection of a new factory at Lansing to have a capacity of 10 trucks per day. The capacity of the plant at Charlotte, Mich., has been trebled by the new $1,000,000 corporation headed by H. M. Lee, which purchased the Duplex Truck Co. several months ago.

The Universal Portland Cement Co., Chicago, announces the appointment of P. D. Van Vliet as publicity manager. Mr. Van Vliet left Cornell with the degree of Civil Engineer to take up work with The Arnold Co., Chicago, in hydro-electric and irrigation design. In 1910 he entered the publicity bureau of the Universal Portland Cement Co. as writer of one of its semi-technical house organs.

The Evinrude Motor Co. of Milwaukee, Wis., manufacturers of the Evinrude rowboat and canoe motor, has increased its capital stock from $350,000 to $600,000 to engage in the manufacture of internal combustion, heavy oil engines. Construction of a large modern plant will be begun at once, the site of which will be in the city being about definitely decided upon. The present line of rowboat and canoe motors will be maintained.

The Pulsometer Steam Pump Co. has recently opened a branch office at Hattiesburg, Miss., which will be under the management of J. L. Welborn. A complete line of regular size pulsometers will be carried in stock to allow prompt shipments. Mr. Welborn has been prominently identified with the success of the Wheland Co. of Chattanooga, Tenn., the largest producers of small machinery in the world. He has created a new field for the pulsometer in handling sand and gravel for commercial purposes, which consists of pumping the sand and gravel direct from the source of supply into open cars ready for transportation.

Building and Structural Issue
of

Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

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THE HEAT LOSS FROM BUILDINGS AND HOW TO REDUCE IT.

Coal has been selling at almost prohibitive prices this winter. Editorials on the extortion of the "coal barons" and the "middlemen" have appeared in all daily papers. Yet what daily paper has published even a hint as to how the consumption of fuel can be decreased without decrease of household comfort?

Some months ago Engineering and Contracting published an editorial article in which it was shown that about 75 per cent of the heat loss in buildings occurs from conduction through the window panes. It was then shown that by "double glazing"—that is, double window panes in each sash—about half this heat loss could be eliminated.

In our Building and Structural Monthly issue for February we published the results of recent tests on the transmission of heat through single and double glazed windows, completely confirmatory of our estimate that there is almost half as much heat lost through a double glazed window as through a single glazed window. Consider the economic significance of this fact, and then ask yourself whether there is not as much need for publicity as for scientific research. What is the use of discovering physical facts if those who can apply the data are not taught the how, the when and the why?

We engineers are particularly charged with the public duty of disseminating knowledge about scientific subjects when such knowledge will add to human comfort and economy. Yet how many of our readers have thought it worth their while to write to the editors of their daily papers enclosing a clipping of an engineering article containing data that the public should know? Don't be always "letting George do it," for "George" is very apt not to do it.

Here is the modern theory of heat conduction, a theory that you will find in no text book on physics, and in no text book on building design:

Adhering to the surface of every solid exposed to the air is a thin film of quiescent air. This quiescent air is an extremely poor conductor of heat, so that, although the air film is thin, its resistance to the passage of heat is considerable. We have, then, three layers of matter through which heat must pass from the inside of a building to the outside, namely, a film of air on the inside, a pane of glass, and a film of air on the outside. If a wind is blowing, the film of air on the outside is reduced in thickness, and the heat loss is increased.

Now suppose we double glaze the window, leaving an air space of, say, three-fourths of an inch between the panes. We then have four films of air instead of two, and a wind can affect the thickness of only one film of air. So that in windy weather the double glazing is even more beneficial than in still weather. Yet in still weather the heat loss through windows can be almost cut in two by double glazing!

Considering the relatively small cost of double glazing as compared with single glazing, there is not a house in the northern part of America that could not very profitably be double glazed. What is true of houses is true of offices and factories. The latter, in fact, would be the greatest gainers, because of the proportionately large area occupied by windows.

It has been objected that double glazing permits the condensation of moisture between the two panes of glass, but this difficulty is overcome by boring small holes through the outside panes of glass, or in any way that admits small quantities of cooler air from the outside. This does not disturb the air films between the panes.

It has also been objected that dust will find its way into the air space between the panes, and make the windows dirty. But this could be fully overcome by the use of specially designed sashes in which any air that enters from the outside must pass through absorbent cotton or the like.

All objections to double glazing can be readily overcome, and double glazing itself will enable all of us to overcome some of our objections to our coal bills.

ERNEST L. RANSOME.

One of the great pioneers of reinforced concrete construction has passed away. Ernest L. Ransome was an inventor to whom Americans owe a greater debt than could ever be repaid. Only a few weeks before his death we commented editorially upon his remarkably useful inventions, and in a gracious letter he acknowledged appreciation of our comment.

The editor had the good fortune to know Mr. Ransome personally, and from his own lips to hear much of the history of his early experiments. Thus, when an architect in San Francisco wished to find a cheaper sidewalk "roof" for a basement than one made of steel I-beams and brick arches, Mr. Ransome's advice was asked. Within a few hours Mr. Ransome had solved the problem, and in a characteristically novel fashion. For brick arches he substituted a concrete slab, and for steel I-beams he substituted steel rods bedded in the concrete. But, as he said, he feared that under the tension of a load the rods would slip in the concrete; so his first idea was to thread the ends of the rods and put nuts on the ends. Then it flashed upon him that he could make the entire rod into a "threaded rod" and the entire concrete into a huge "nut" threaded thereon. Forthwith he took a rod of rectangular section and twisted it in a lathe, making what afterward became famous as the "Ransome twisted bar reinforcement."

The first reinforced concrete slab was made, and a new era of building construction was initiated. Nor was Mr. Ransome slow in perceiving the economic possibilities that now presented themselves. He began to design and erect reinforced concrete bridges and buildings, improving steadily in his designs of details, and coincidentally in his methods of manufacturing and placing concrete. His "non-tilting batch mixer"—a device of extreme simplicity—was first designed for his own contract work, and later put upon the market. His tower and hoisting bucket for building work was a still later step, and then came his system of chuting concrete from the tower into the forms.

Mr. Ransome's mind was always active upon some improvement or some new device, yet, unlike many inventors, he did not cease his labors on an invention before it was fully developed. He was exceedingly practical and painstaking. But the necessity of carrying on his business often left him with but few hours to devote to inventive work.

It had often seemed to the writer that society loses enormous benefits every year because men of genius are forced to "earn their daily bread."

If we pause but a moment to consider the rarity of highly inventive talent, we are struck with the great economic loss that occurs whenever an inventor is held, even for an hour, from the exercise of his genius. Was it Edward Bellamy who, in his "Looking Backward," pictured an ideal social state wherein each man was given to do the thing that he could do supremely well? Perhaps such a Utopia is coming sooner than Bellamy dreamed, although not as he dreamed it, and, when it comes, our Ransomes will be free to add not merely one or a score or a hundred labor-saving things to the world's stock, but five or ten times the number.

Mr. Ransome was a man who took the kindliest and most gracious interest in those about him. No person could see him often without feeling both a profound respect for his ability and a great liking for his character. He was modesty personified as to his achievements, and told how each invention had "evolved" in such a simple, matter-of-fact way that it seemed as if almost anyone might have "evolved" it. But, as some one remarked, the ease with which a powerful and skilled intellect works is the most deceptive ease in the world, as speedily becomes apparent when a weak and untrained mind attacks the same sort of a problem.

Mr. Ransome's father, Frederick Ransome, had also been an inventor, and had patented an artificial stone in 1844. The early training under his father, coupled with his inherited originality, made Mr. Ransome eager to follow a career as an inventor. Now that career has ended, rich in achievement and fascinating as a romance. The history of Ernest L. Ransome's life would form a chapter that would match well with those that Samuel Smiles, in his "Self Help," wrote nearly a century ago about the great inventors of his day.

THE PROPOSED NATIONAL SOCIETY OF STRUCTURAL ENGINEERS.

The editor has received a score of letters from engineers who have expressed interest in the plan to organize a national society of structural engineers. He will be glad to hear from more engineers who see in the suggested society a means of promoting the interests of this branch of the civil engineering profession.

The chief engineer of a large bridge company recently told the editor that three-fourths of his staff was engaged in the design of structural steel work for buildings. Only a few years ago half his staff was occupied on building design and the other half on bridge design. A decade ago the ratio was three engineers on bridge work to one on building work.

Making due allowance for the effect of the war, the trend of structural engineering is unmistakably toward relatively greater activity in the building field than in the bridge field. This fact should be very significant to structural engineers, and particularly to those who are weighing the pros and cons as to joining a new society of structural engineers.

Steel bridges have been standardized to such an extent that engineers are not likely to find so fruitful a field in bridge design as formerly existed. The smaller spans of reinforced concrete bridges are likewise being stardardized, both by railway companies and by state highway departments. But the design of buildings is never likely to be thus standardized. Indeed, we are now entering an era of experiment and invention in the building field which is enticingly attractive to original and ambitious engineers.

A national society of structural engineers could perform a great service to its members, not only by stimulating them in their search for more economic and more artistic solutions of building problems, but by giving national publicity to the accomplishments of engineers in the design of architectural structures.

This is an age of specialization as well as an age of consolidations. Let us have greater variety of purpose among engineers through affiliations of all engineering societies. But let us not overlook the equal importance of developing more societies whose members are specialists. This is evolution, "integration with concomitant differentiation," as Spencer puts it. Only they who are blind to the forces of evolution attempt to obstruct the development of new engineering societies of highly specialized nature.

Already there are scores of different national specialized engineering associations in America. In a few years there will be hundreds of such associations. The cry that there are too many engineering societies is not the voice of wisdom but of unthinking protest against progress.

In Illinois alone almost 1,000 structural engineers have been licensed by the state. No one knows how many structural engineers there are in America, but the number is in excess of 15,000. It should be possible to enroll at least one in every five as a member of a national society of structural engineers.

The editor will be glad to receive letters from engineers who are interested in this proposed society. Ultimately an organization will be effected.

WHO WILL BE THE FIRST COUNTY MANAGER?

Some months ago we suggested that in view of the success of the "city manager plan," it would seem wise to try a "county manager plan," and that county engineers might thus be put in executive charge of county affairs.

On Feb. 27, the citizens of San Diego County, California, voted on a charter under which the county manager plan would have been adopted, but unfortunately the charter was defeated. However, we venture the prediction that if publicity work is vigorously continued in San Diego County, another election will show a different result.

Elsewhere we publish an interesting letter from Mr. H. S. Gilbertson, executive secretary of The National Short Ballot Organization, relative to the temporary defeat of the county manager plan in San Diego. We also publish a list of city managers and their respective salaries. While most of the salaries are too low, still it should be noted that the average salaries of city managers exceeds the average salary of city engineers in cities of corresponding size.

There are about 1,000 cities of more than 8,000 population, and eventually all of them will be under some form of management by an executive corresponding to a "city manager," whose functions are not only more extensive than those of a "mayor," but less restricted by city councils. Including the smaller towns there will probably be 4,000 to 5,000 places for "city managers," when the new type of city government becomes universal. There are now 1,700 counties that have county engineers, but there are 1,000 additional counties without engineers; so we may safely predict that 2,500 counties will eventually require the services of 2,500 county managers. City and county managers combined are likely to exceed 7,000 in number, and there is every reason why most of the number should be civil engineers.

Engineers throughout America should not only cooperate to hasten the era of engineering management for cities and counties, but each engineer should use his individual influence toward this end without waiting for co-operative action. The engineer as a manager has arrived. What engineer will have the honor to be enrolled as the first county manager?

The Southern Ry. will replace all frame trestle on 228 miles of line between Morristown, Tenn., and Salisbury, N. C., with permanent structures of steel and concrete. The work includes the erection of 18 new steel bridges, the encasing of five stone and brick arches in reinforced concrete and the elimination of 119 trestles.

THE COUNTY MANAGER PLAN.

To the Editor: In the issue of Engineering and Contracting for November 29, 1916, you have an editorial entitled "Why Should Not County Engineers Become County Managers?"

It may interest you to know that under the county home rule provision of the California constitution, San Diego County recently drafted a charter which provided for the office of county manager, who was to be ex-officio county engineer and road master. It is obvious of course that the county manager under these circumstances would have to be a technical man.

The charter unfortunately was defeated on Feb. 27th, but it is nevertheless a sign of what counties are coming to. It is most encouraging to find so much interest in the engineering profession in improved methods of government. Apparently engineers everywhere are coming to see that the profession has great public work to perform in the coming years under every branch of government and that government work opens up new opportunities for engineers. This organization is in correspondence with a great many such technical men, owing to the part it has played in the development of the city manager plan. We want to hear more and more from the engineers and to get their support for every movement which looks in the direction of solid responsible organization of government to secure efficiency and democracy.

H. S. Gilbertson,
Executive Secretary the National Short Ballot Organization.

New York City.

[The February, 1917, Short Ballot Bulletin, the official publication of the organization of which Mr. Gilbertson is the executive secretary, contains the following account of the scheme of county government proposed by San Diego County, California.—Editor.]

> On Feb. 27 San Diego County, Cal., votes on a proposed new charter under the home rule provision of the California constitution, whereby counties are permitted to frame their own form of government just as the cities do. It is a most original and progressive instrument and exceedingly sound. It shortens the ballot radically, eliminating or consolidating about a dozen technical offices that are now elective. A board of supervisors, nominated from districts but elected at large, for a term of four years, in rotation (five at one time and four others two years later), is made the governing body of the county, with authority to hire and fire the county manager under whom is concentrated the administrative business of the county. The sheriff and district attorney are the only other elective offices. The supervisors receive their actual expenses but no salaries. Sweeping powers are granted to the supervisors—sufficient, it would seem, to eliminate the need for special enabling acts in the future.
>
> The manager, the coroner, county clerk, county counsel, public defender, superintendent of schools, treasurer, etc., are all appointed by the board of supervisors from the civil service commission's eligible lists.
>
> Certain consolidations of offices are interesting. The coroner is made ex-officio the public administrator. The assessor is ex-officio tax collector and license collector. The county manager is ex-officio road commissioner, and the county clerk is ex-officio registrar of voters, clerk of the board of supervisors, and clerk of the superior court.
>
> The civil service commission is appointed, one member by the governor, one by a majority of the judges of the superior court of the county, and one by the board of supervisors, the terms being six years, expiring in rotation. They are removable by a vote of seven supervisors. Their support is guaranteed by a specific tax, and practically all officers are put under their jurisdiction. They certify the payroll, advise with and assist the supervisors in fixing salary schedules, and no compensation for any position under civil service may be increased or reduced without their consent. From its own certified lists it appoints the county auditor and the county assessor. The manager may remove any of the appointive officers (except the auditor and county counsel) after warning and subject to reversal by the commission.
>
> The auditor compiles the annual budget, which goes to the supervisors, accompanied by the recommendations of the county manager, and the board of supervisors may reduce items but not increase them beyond the manager's recommendation.
>
> The elimination of various township officers is facilitated by the provision whereby the county, on request from any of the townships, must take over various items of work and perform them at cost.
>
> The department of public welfare, doubtless for some special local reason, is separately constituted altogether, consisting of seven members, two appointed by the governor, two by the court, and three of whom the county manager must be one, appointed by the board of supervisors. The county manager is chairman. The terms are six years, in rotation, and a specific tax of 20 cents per hundred dollars is provided for this department's support. It has charge of the hospital, the poor, the indigent dead, the detention home, and probation, and it constitutes the board of health.

INFORMATION WANTED ON INTERPRETATION OF CONTRACT CLAUSES.

To the Editor: I would like to have information on the following matter, which may be of interest to some others of your readers:

A contract contains the following clauses:

> The said party of the second part shall complete the several portions and the whole of the work comprehended under this agreement by and at the time hereinafter stated, towit:..........................
>
> That in the event the said party of the second part does not complete the aforesaid work by and at the time above specified for its completion, he shall pay to the said party of the first part the sum of Fifty Dollars for each and every day which said work shall remain uncompleted after said date.

There are no references in any way in the contract to the foregoing clauses.

Has such a provision been construed anywhere by the courts, and are there any references you can give pertaining thereto?

There seems to be an impression among some contractors that such a provision will not hold, because there is nothing in the contract providing for a premium to be paid the "party of the second part" if he completes the work ahead of time. Has this point been covered by the courts, and can you give references to such action or construction? If it has not been whence comes the impression above referred to?

The contract also contains the following:

> It is further expressly stipulated and agreed that all of the buildings, equipment, machinery, and other things required to be done and performed, or furnished by the said party of the second part under the terms of this contract, will be placed, constructed, and performed at the exact location as shown by said plans and specifications.

After the work was begun on the site indicated by the plans, the party of the first part directed that it be stopped, because another site had been procured, and without getting the consent in writing of the party of the second part to the change in location, an extension of time was given, which was acknowledged by the party of the second part. No information was given the bondsmen of the change in site, except possibly a notification of the extension of time. The party of the second part went ahead with the work, following the original plans as nearly as possible in the location finally selected by the party of the first part.

In view of the clause in the contract that the "buildings, equipment, machinery and other things required to be done and performed, or furnished by the said party of the second part under the terms of this contract, will be placed, constructed and performed at the exact location as shown by said plans and specifications," does this change invalidate the contract?

The bondsmen not having been notified of the change, are they released?

If the party of the second part goes ahead with the work in the new location, as stated, can he collect "from the party of the first part," for whatever he does, assuming that he constructs the buildings and furnishes and erects the machinery and other things as nearly in accordance with the plans for the original location as possible, or as directed?

If the plans furnished give measurements of fittings that are obsolete, and pipe lengths based on them and on the location of machines that are not correctly determined as develops when the machine plans are received, in what position do these things place "the party of the second part"? Has he any recourse? What effect do such discoveries have on the contract?

It occurs to me that a discussion of the above matters might be of interest to engineers and to contractors, and of special importance to some of them. Is it asking too much of you to bring such a discussion, and such court references, out in your paper? I hope you will not so consider it.

[We are very glad to give space to the above letter. We hope that some of our readers who have had experiences in these matters will furnish the desired information.—Editor.]

LOGIC FOR ENGINEERS.

III. The Categories of Energy (Number).

By Halbert P. Gillette.

[The previous articles of this series are: I. Energy and Cause-Effect (Jan. 31), and II. The Lenses and Feelings (Feb. 28).]

The Categories.—Aristotle introduced the use of the word category in logic to denote a "highest notion" or "ultimate idea." Locke used the term "original idea" to denote what Aristotle would have called a category. Kant reverted to the word category to denote a "highest intellectual concept." It seems desirable to retain the word category in logic, but to restrict it to the four abstract terms essential in discussing energy quantitatively, namely: (1) Number, (2) time, (3) distance or space, and (4) mass.

Aristotle's categories were ten: (1) Substance, (2) quantity, (3) quality, (4) relation, (5) action, (6) passivity, (7) where (location), (8) when (time), (9) relative position of parts, and (10) state or habit.

Locke's "original ideas, from whence all the rest are derived, and of which they are made up," were: (1) Extension, (2) solidity, (3) mobility (or power of being moved), (4) motivity (or power of moving), (5) perceptivity (or power of perception, or thinking), (6) existence, (7) duration, and (8) number.

Kant's "highest intellectual concepts" were given under four general classes and 12 subclasses. The general classes were: (1) Quantity, (2) quality, (3) relation, and (4) modality (or the degrees of possibility and actuality). His quantity categories were: (a) Unity, (b) plurality, and (c) totality. His quality categories were: (a) Reality, (b) negation, and (c) limit between these. His relation categories were: (a) Substance and accident, (b) cause and effect, and (c) action and reaction. His categories of modality were: (a) Possibility and impossibility, (b) actuality and non-actuality, (c) necessity and non-necessity.

Modern formal logic gives three categories: (1) Qualities (or singular characters), (2) simple relations (or dual characters), and (3) complex relations (or plural characters).

The mere naming of such lists of categories serves two purposes: First, it gives a general insight into what has been meant by the word. Second, it shows that there has been lack of agreement as to what the "highest intellectual concepts" are.

Speaking of his "original ideas," or categories, Locke said:

> For by these, I imagine, might be explained the nature of colors, sounds, tastes, smells, and other ideas we have, if we had but faculties acute enough to perceive the severally-modified extensions and motions of these minute bodies which produce these several sensations in us. * * * * I do not say, that the nature of light consists in very small round globules (corpuscles), nor that the nature of whiteness consists in such a texture of parts as gives a certain rotation to these globules when it reflects them; for I am not now treating physically of light or colors: but this, I think, I may say, that I cannot (and I would be glad anyone would make intelligible that he did) conceive how bodies without us can any ways effect our senses, but by the immediate contact of the sensible bodies themselves, as in tasting and feeling, or the impulse of some insensible particles coming from them, as in seeing, hearing, and smelling; by the different impulse of which parts, caused by their different size, figure, and motion, the variety of sensations is produced in us.

When it is remembered that Locke wrote this hypothesis 230 years ago, we can better appreciate the acuteness of his intellect. His great "Essay on the Human Understanding" is not only intensely interesting but very profitable reading to this day, and a remarkable example of combined clarity of thinking and clarity of expression. Indeed, are not these two always twins?

Locke gives what he calls the "primary or real qualities of bodies," namely: Solidity, extension, figure, number, and motion or rest. Of number he says "it is the most universal idea we have, for number applies itself to men, angels, actions, thoughts—everything that either exists or can be imagined."

It will be noted that Locke's "primary or real qualities of bodies" agree quite closely with the four categories of energy—number, mass, space and time. His "solidity" is in reality mass. His "extension" and "figure" are spatial "qualities." His "motion" is a function of distance and time.

Lacking the modern conception of energy, Locke naturally failed to make a wholly rational enumeration of the categories in their simplest form. Kant's classification is largely verbal, being not even as good as Aristotle's.

Number.—Number is a conception traceable to the action of every organ of sense and feeling, and is accordingly inseparable from every idea. But what is the underlying "likeness" of the vast maze of unlike things in the universe that makes them all numerable? The answer, as I conceive it, is found in the fact that motion is rarely uniform, but changes. Each change of motion that our bodily organs can perceive is perceived through some change in the chemical composition of those organs themselves. Every change may be called a unit, and any aggregation of units may be called a number.

There is no such number as naught or zero (0), mathematicians to the contrary notwithstanding. Naught is the absence of all number. The presence of a zero in a series of Arabic numerals merely indicates the absence of a number of the given "order" and preserves the "order" of the other numerals, so as to indicate the total number.

Number, being an abstract idea, is commonly supposed to have no necessary connection with concrete things. This is a false conception, countenanced though it is by most people. In defining the word abstract, the Century Dictionary falls into the common error, for it says:

> Abstract.—Conceived apart from matter and from special cases; as, an abstract number, a number as conceived in arithmetic, not a number of things of any kind.

In this definition the word matter evidently relates to what I call material energy-groups, such as iron, stone, wood, etc. Each of these has weight, and weight is an abstract term, yet weight is not conceivable apart from matter. Each of these materials can be numbered, and number is an abstract term, yet number is inconceivable apart from an energy-group of some sort. "An abstract number is not a number of things of any kind," says the Century Dictionary, and there ends its definition, leaving a false idea of "number" as well as of "abstract." To be correct a definition must be complete, and in this case it should read: An abstract number, although not a number of things of any specified kind, is a number of some kind of things. Analogous definitions of other abstract words may be framed, thus: Whiteness, while not an attribute of any specified thing, is yet an attribute of some kinds of things. In brief, no abstract word can denote something entirely apart from some energy-group.

No abstract word is more general in its abstraction than is number, for number applies to every sense-record or feeling-record made by any energy-group. When we name a pure or abstract number, say nine, we tacitly name "in blank"; and the implied blank after the number may apply to any thing, but it must apply to some thing. Thus, when we say nine, we inevitably connote nine somethings—pounds, men, stones, etc., etc., ad infinitum.

We cannot add together numbers relating to unlike things and get a sum that has significance.

Since every cause of effect is an energy-group, it is meaningless to speak of a pure number as if it were a definite cause or effect of anything, although every cause is numerable.

Number is an ultimate idea, which resists every attempt to resolve it into simpler or component ideas. Every change is numerable; every difference is numerable. Since changes and differences depend, in the final analysis, upon variations in combinations of ultimate corpuscles and their motions, it is evident that a final limit to subdivisibility, and therefore to enumeration, will not be attained until the ultimate corpuscles in an energy-group are numbered. It is well to keep this ideal goal in mind, even though it be unattainable, for it serves to clarify the reason why all things are susceptible of quantitative treatment, and it serves also to show why there is quantitative relationship between phenomena that seem outwardly so different as to be wholly unrelated. This last consideration will receive exemplification in the sixth article of the series.

If we clearly apprehended the significance of abstract words in general, and of the abstract word number in particular, we shall free ourselves of many a metaphysical delusion, and thereby come oftener to form a habit of clear thinking that leads onward to a definite understanding of the phenomena of inanimate and animate nature. If, however, we fall into the Kantian habit of regarding abstract words as "pure thought" free from the trammel of material substance, we shall whirl aimlessly without advancing, yet, deceived by the dizziness of the turning, we shall believe that we are moving onward because we feel ourselves moving.

Quantity.—Descartes, the great French scientist and philosopher has said: "Quantity and number differ only in thought from that which has quantity and is numbered." The idea thus conveyed is not very clear. Something is elucidated by this statement of W. K. Clifford:

> The science of number is founded on the hypothesis of the distinctness [or separateness] of things; the science of quantity is founded on the totally different hypothesis of continuity.

Yet it is a fact that we may assign number to every continuous body by rating it in units of its own kind. Then do we assert, by implication, the separability of every continuous body? Let us see.

We speak of a number of men, not of a quantity of men. Conversely, we speak of a quantity of sand, not of a number of sands, even though the grains of sand are innumerable. Does, then, the real distinction between number and quantity reside merely in the difficulty involved in separately counting the ultimate results? It seems to me that it does. This difficulty may spring either from the magnitude of the task of enumerating a vast lot of separably sensible units, such as grains of sand, or from the limitations of our organs of sensation, which preclude the direct sensing of the ultimate units as separate things. This question is so closely interwoven with the questions yet to come that it is wise to pause until we have examined certain characteristics of the organs of sensation.

Actions of the Sense-Organs.—The five sense-organs, as we have seen, are actuated, or stimulated to action, by energy in some of its forms. It is well known that the nerve molecules are exceedingly complex. It is also well known that different intensities of the same general kind of energy initiate different kinds of chemical reaction. Thus, the brush of a feather will explode many of the iodides, whereas it requires a very intense blow to explode nitroglycerin; and no intensity of impact will explode ordinary gunpowder unless the impact results in a very high temperature.

We may picture each sense-organ and its nerves as being a complex of different chemical groups and strands, each responding to different degrees of intensity of the same kind of energy, and none of them responding at all unless the intensity of the particular kind of energy lies between certain limits. This enables us to understand how the sense of hearing perceives a wide gamut of tones from the lowest audible pitch of about 16 pulsations per second to the highest audible pitch of about 30,000 pulsations per second. Similarly the various visible colors have different wave-lengths, corresponding to different intensities of etherial energy. Similarly a very slight pressure on the external nerves of touch is a touch, while a pressure on the internal nerves of touch associated with the muscles yields a "sense of muscular strain" or weight.

The organs of touch are undoubtedly different in chemical composition in different parts of the body, producing, perhaps, species of touch sufficiently unlike to be regarded as entirely separate kinds of senses, such, for example, as the sense of temperature, as distinguished from the tactile sense.

Each of these different chemical reactions in the nerves, whether effected by a different kind of energy or by a different intensity of the same kind of energy, is sensed as a different "quality."

Thus we come to a better perception of the nature of sensible "qualities." But it remains to understand how continuity of sensation is engendered.

Chemical action is not instantaneous; it requires time. Hence there results what we may call persistence of sensation, which is a function of the duration of a chemical change in the nerve-stuff. We are all familiar with the persistence of vision, for upon this phenomenon depends the successful operation of the cinematograph or "moving-picture" machine. But every series of sensations is like that of sight in its capability of being "fused" or rendered continuous. If the finger is held against a blunt-toothed revolving wheel, and the speed of its revolution increased sufficiently, the sensation of roughness produced by the separate teeth will gradually vanish, finally giving place to a sensation of smoothness. This smooth sensation occurs when the interval of contact of successive teeth is about one five-hundredth of a second. Similarly a series of small holes in the outer edge of a wheel is felt to be a continuous slot in the periphery, if the wheel revolves rapidly.

If successive sensations occur at intervals less than the duration of sensation, then there results a sensation of continuity.

If we add to this generalization one more respecting the action of the sense-organs, we shall have a definite understanding of continuity.

Each sense-organ has, at its receptive end, groups of "sensient elements." Thus, the retina of the eye is a mosaic of "retinal elements," variously spaced but most closely grouped at the center of the retaina in what is called "the yellow spot," which covers an area having 2 mm. horizontal and 0.8 mm. vertical diameter. Within this "yellow spot" there is a very highly sensitive area, 0.2 mm. diameter, containing 2,000 retinal elements, each having a diameter of about 0.004 mm. It has been found that the smallest visual angle in which two distinct points may be seen is 60 seconds. If the visual angle is smaller than 60 seconds, the two points are seen as one point only. Now, it happens that a visual angle of 60 seconds projects on the retina an image of 0.004 mm. diameter. Hence it follows that, when only one point is seen, it is not because more than one point does not exist, but because only one retinal element is thrown into action, or excited. Incidentally it is interesting to know that a brilliantly illuminated point one six-hundredth of an inch in diameter is visible, although it subtends a visual angle of only one-quarter of a second.

The "tactile elements" show corresponding likeness to the retinal elements, but the distance apart of the sensitive elements of touch is much greater than of sight. Two points less than 1.1 mm. apart if placed on the tip of the tongue are sensed as one point. Whereas two points may be 68 mm. apart on the center of the back and yet be sensed as one point. There are "hot spots" and "cold spots" on the skin, where temperatures hotter or colder than the normal skin temperature are perceived as distinct sensations.

If the sense of touch were no more delicate in any part of the human body than it is in the center of the back, then any two or more points within a circle 68 mm., or 2.7 in., diameter would be sensed as one single point if touched. Conceive a human being thus restricted in ability to determine the degree of continuity of matter and gifted with no reasoning power. He would then assert all matter to be continuous, even though it were made up of points spaced 2.7 in. apart!

From this conception it is easy to pass to an understanding of our "instinctive feeling" that visible solids are continuous, because our eyes, even when aided by the most powerful microscope, cannot see the ultimate particles of matter as discrete or separate things. However, we infer that a matter is made up of separate particles because of many phenomena otherwise inexplicable. Yet even a scientist often finds it hard to free himself from the illusion that matter is continuous. It is not easy to make one's self regard an atom as a sort of microscopic solar system with the bound corpuscles as distinct planets, between which the spaces are relatively great. Yet such is probably the case, and already there is the term, "the astronomy of the atom."

If several separate external energy-groups act simultaneously on a sense-organ, but over an area that includes only one sensitive nerve-element, the resultant sensation will be that of a single energy-group, giving an impression of continuity to what really are separate external energy-groups.

The two preceding generalizations and their attendant discussions will prepare us not only to understand the distinction between number and quantity, but to see more clearly into the nature of matter itself because of the removal of certain sense-developed illusions about its continuity.

Units of Quantity.—As above stated, any change that is registered by the nerve-stuff is a unit. And a group of such changes is a number. If the changes are so numerous as either to produce a sensation of continuity or to make it excessively laborious to enumerate the separate changes, then the continuous or composite group of changes is called quantity. A unit of quantity is any relatively small quantity taken as a standard with which to measure or enumerate quantities of the same kind.

Every standard unit of quantity is itself measurable in smaller units of quantity of the same kind, until at last the corpuscle in motion is reached as the ultimate unit.

Throughout the entire gamut of units, from the most complex down to the simplest, no unit can be used to measure quantities of a different kind or class than that to which the unit belongs. In other words, one kind of energy-group is measurable only in units of its own class. This generalization has a very significant corollary, namely: When any energy is a function of two or more different kinds of energy, or categories of energy, it is because these different kinds are themselves proportionate to the universally common and ultimate units of energy—the corpuscles in motion.

The importance of this generalization will be made clearer in the sixth article of this series.

Lest the reader think that such discussions as these are more germane to philosophy or higher physics than to logic, I would state that I believe Herbert Spencer to have been partly right when he said: "Logic is as much a division of the science of objective existence as mathematics," and that "Logic formulates the most general laws of correlation among existences considered as objective" (Psychology, II, Chap. 7). I think he made an unwise—and certainly an abnormal—classification when he segregated Reasoning from Logic, as he did when he stated that: "Reasoning formulates the most general laws of correlation among the ideas corresponding to objective existences," making Reasoning a "subjective science" to be treated entirely apart from Logic as an "objective science."

The old metaphysical distinctions between "subject" and "object" are mainly distinctions founded on ignorance. When the perceiving "subject" was supposed to be a mere "observer" of "external objects," and in no wise a co-acting energy, then it was undoubtedly impracticable to discuss the principles of "matter" and of "mind" as composite elements in one great energy-complex. Today, if we are to learn how to reason most effectively, we must study the most general principles of energy in its various manifestations, with the object of co-ordinating these principles into a system. This co-ordinated system becomes Logic.

The categories of Time and Space will be discussed in the next article of this series.

A bill is before the Philippine Legislature appropriating $2,516,155 for public works during the current fiscal year. Of the total $1,500,000 is for highway improvements.

DIAGRAM FOR USE IN DESIGNING AND CHECKING CAST IRON OGEE WASHERS.

Contributed by W. S. Wolfe.

The object of the accompanying diagram is two-fold: first, to give the diameter of washers required to distribute the given load without exceeding a given allowable unit pressure on the wood, and second, to give the required thickness when the allowable tension in the cast iron is known. The diagram may be used for checking standard sizes of washers, or for designing.

To find the required diameter "D": In the column on the left side of the drawing find the load to be distributed and then move horizontally to the right until the 200-lb. vertical line is intersected. Then follow the inclined lines until the vertical line representing the allowable pressure on the wood is intersected, then follow parallel to the horizontal lines and read off the required diameter on the right-hand scale.

To find the required thickness "T": Follow down the vertical line representing the allowable pressure on the wood until the curved line near the bottom of the diagram representing the allowable tension in the cast iron is intersected. Then move to the right parallel to the horizontal lines and the value of T/D is found on the scale at the right-hand side of the drawing. If the diameter D already obtained is multiplied by this value of T/D, the required thickness is obtained.

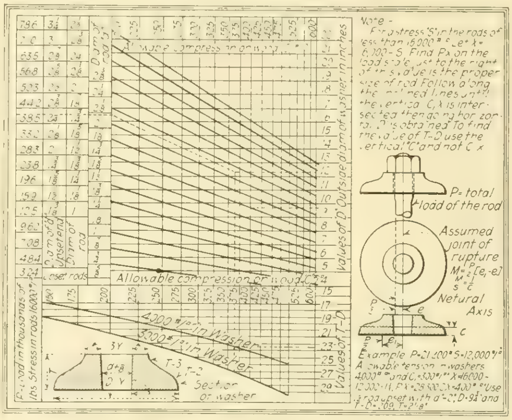


Diagram for Use in Designing Ogee Washers.

Three of the columns on the left side of the sheet simply give sizes of rods which will carry the loads given in the other column when their fiber stress is 16,000 lb. per square inch. Both upset rods and those which are not upset being given. The note on the right tells how to obtain the correct size of rod when a stress other than 16,000 lb. per square inch is used. For such cases, if the size of the rod is obtained from a handbook, the note does not apply.

Steel Prices in 1916 and 1917.—The following figures from a table printed in The Iron Age on Jan. 11, 1917, show the prices on various lines on Jan. 10, 1917, and Jan. 12, 1916:

	Jan. 10, 1917. Cts.	Jan. 12, 1916. Cts.
Finished iron and steel, per lb. to large buyers:		
Iron bars, Philadelphia	3.159	2.259
Iron bars, Pittsburgh	3.25	1.95
Iron bars, Chicago	3.00	1.75
Steel bars, Pittsburgh	3.00	2.00
Steel bars, New York	3.169	2.169
Tank plates, Pittsburgh	4.25	2.25
Tank plates New York	4.419	2.419
Beams, etc., Pittsburgh	3.25	1.90
Beams, etc., New York	3.419	2.069
Skelp, grooved steel, Pittsburgh	2.85	1.80
Skelp, sheared steel, Pittsburgh	3.00	1.90
Steel hoops, Pittsburgh	2.45	2.00
Sheets, nails and wire, per lb. to large buyers:		
Sheets, black, No. 28, Pittsburgh	4.50	2.60
Sheets, galvanized, No. 28, Pittsburgh	6.25	4.75
Wire nails, Pittsburgh	3.00	2.10
Cut nails, Pittsburgh	2.95	2.00
Fence wire, base, Pittsburgh	2.95	1.95
Barb wire, galvanized, Pittsburgh	3.85	2.95

FACTORS AFFECTING THE COST OF STRUCTURAL STEEL.

By E. W. Pittman, Manager, McClintic-Marshall Co

The factors affecting the cost of producing and the cost of purchasing structural steel work were discussed in two papers presented recently before the Engineers' Society of Western Pennsylvania and printed in the December Proceedings of the Society. Abstracts of these papers follow:

Factors Affecting Cost of Structural Steel Shop Work.

The largest single factor in determining the cost per pound of steel in a structure is the design rather than any special or unusual requirements as to workmanship. If utility and economy are the governing considerations, the design should be as simple as possible. The number of members and the number of pieces in each member should be reduced to a minimum. Complicated connections and splices and bent work should be avoided as far as practicable. The use of a great variety of sections and of sections not often rolled should also be avoided. This is especially important if quick delivery is a consideration, as it is easier to procure mill rollings of a few standard sections than of a great many including some unusual ones such as T's, Z's and deck beams. It is always well to go over a design after it is finished and make a list of the different kinds of sections shown. Generally it will be found possible to greatly reduce the number without materially increasing the weight. In ordinary structures such as small bridges, viaducts and buildings, it is well to make liberal use of beams, channels and H columns in place of short lattice struts and trusses and small built up columns. It is interesting sometimes to observe the transformation in a mill building design at the hands of a bridge company with a financial stake in simplifying the work. I have seen designs made up of a fretwork of lattice members, short trusses, riveted columns and plate girder crane runways redesigned in the interest of economy with H columns in place of built up columns, beams in place of roof trusses and lattice struts and girder beams in place of plate girders. The cost per ton to the purchaser for the manufacture of the original design, exclusive of the cost of steel, might be about $15 to $18 a ton, while the cost for the revised design should be about half this amount. Of course, the substitution of rolled sections for built up sections sometimes increases the weight slightly. Using these figures as a basis of calculation, however, and knowing the base price of steel at any time, it is an easy matter to determine just what increase in weight would be compensated by the decrease in cost of fabrication.

In the design of shallow plate girders it is sometimes economical to increase the thickness of the web plate 1-16 in. beyond the thickness required to resist the shearing stress when such increase renders it possible to dispense with stiffener angles and fillers that would otherwise be necessary. Likewise it is often economical to distribute a column load over a masonry footing by means of a thick slab rather than by means of a number of stiffener angles, wing plates and diaphragms at the base of the column. Stiffeners at the bottom of a column require careful planing and fitting to be effective, and frequently also they involve many hand rivets.

It is often necessary to use two or more different size rivets in a structure. But when this is necessary an effort should be made to avoid as far as possible the use of two or more different size holes in the same piece, as this involves the transferring of the piece to another punch, or else the changing of punches and dies in the machine. This almost doubles the cost of the punching on the piece.

Some of the rolling mills used to issue a card giving fabricating extras on beam work. The extra list on these cards for two or more sized holes in a beam was a considerable item.

Entering or pocketed connections and over-lapping splices, both in the shop and field, should be avoided as far as practicable.

In writing the specifications for workmanship the engineer must consider and determine the requirements for sub-punching and reaming, drilling, planing and templet reaming. The practice of sub-punching; that is, punching holes ⅛ in. or ¼ in. small and reaming to the finished size, after the work is fitted is more common now than it was a few years ago. It insures good matching of holes and good rivets, and is, no doubt, a wise requirement in the case of railroad bridges. But when the requirement is extended to buildings and light bridges and viaducts it probably costs the purchaser more than it is really worth to him. The facilities in modern shops make it possible to punch holes full size and obtain fair matching without any reaming at all. Generally a hot rivet may be easily entered in three-fourths of the holes, but all holes are cleaned out with a five-flute tapered reamer in a portable hand machine. This has the effect of dividing any error in the matching of holes by slightly elongating the mismatching holes, and it is an insurance against any delay in sticking in the rivets. This hand reaming is done on the skids where the work is fitted up and bolted. But if the work has been sub-punched and must be reamed out ⅛ in. or ¼ in. larger, it is cheaper to remove the pieces to the reaming machines and do the work with a three-flute straight reamer made of high-speed steel. This generally involves a great deal of crane service and trucking in addition to the increased reaming cost. The increased cost to a purchaser for sub-punching and reaming probably varies from 60 ct. to $1 a ton. A requirement often seen in specifications is that material over a certain thickness must be drilled from the solid. This is a matter that should be left somewhat to the judgment of the shop, or to the purchaser's inspector, especially if the punched hole is to be subsequently enlarged by reaming. In average bridge steel it is easily possible to punch 11/16-in. holes in ⅞-in. metal, or 13/16-in. holes in 1⅛-in. metal with good results, using a die about 1/16 in. larger than the punch. If the steel is hard, however, this is not feasible. If the steel is very hard and 11/16-in. holes are required, it is often preferable to drill even 11/16-in. metal because of the loss and also the danger from breaking punches. The labor cost of drilling in a well equipped shop is about five or six times that of punching.

In bridge work it has become quite common of recent years to require the assembling and reaming at the shop of important field connections, or else the reaming of such connections through a steel templet. This adds considerably to the cost of fabrication, but it generally saves more in the field than it costs in the shop. This requirement should not be made, however, without a careful study to determine its economy. Sometimes a connection may be reamed cheaper in the field if it is easily accessible without scaffolding.

Some Items Affecting Cost of Structural Steel Work.

By George H. Danforth, Structural Engineer, Jones & McLaughlin Co.

An item of design in which a high cost is frequently incurred to save a small amount of material is in the use of riveted trusses for roofs and similar places, when a simple beam will answer all purposes, and there are a great many cases where roof trusses are used on spans of 30 to 40, or even 45 ft., where a simple beam would answer all the purposes, weigh possibly a trifle more, but cost in dollars and cents considerably less. This feature is, of course, subject to modifications, due to the variation in the price of material and the price of labor. At the present time it would probably be economical to spend a little more in labor to save something in material, but even at the present time the saving, under these conditions, would not be as great as might be imagined, and the greater stability and ease of cleaning and painting that attaches to the use of a simple beam over that of a roof truss, which has a considerable proportion of its surface inaccessible, is plainly evident.

This idea of getting economy by the use of simple sections in place of complex riveted sections is nothing new. In the days when channels were held at prices of 3 ct. and over, with angles and plates about half this price, it was a common practice to make bridge chords, even of small highway bridges, of four angles, two web plates and a cover plate, in place of two channels and a cover plate, the conditions in the prevaling prices for material more than offsetting the additional shop work of using the plate and angle section.

Another item that will occasionally affect costs and also affect delivery is the number of sizes that a designer will put into a structure. For instance, there is not sufficient difference between the dimensions of a 6x4-in. and a 6x3½-in. angle to prevent the use of either size throughout a job, rather than use both sizes. This is also true of 5x3½-in. and 5x3-in. angles, 3½x2½-in. and 3x3-in. angles; also 2½x2½-in. and 2x2½-in. angles. Each size that can be thus eliminated from a job means one less size to be realized before the fabrication of the job can be taken up, and so expedites delivery and reduces the work and troubles in putting through a piece of work.

In this connection it might be well to mention that even nowadays we occasionally run across work wherein tees have been specified by the designer, in happy ignorance of the fact that there is probably not a more difficult section to get, even under normal mill conditions, than such tees.

The same is similarly true, although in a lesser degree, of small beams and channels. Many designers use these sections for lintels, when two or three angles could just as well be used, and which would eliminate any necessity for punching or for separators or separator bolts, and with no appreciable increase in weight.

Going further into detail you will find the matter of detail design, which of course involves the question of shop drawings. It seems impossible to some people to make details without getting rivets into pockets, where they are very difficult, if not impossible, to drive; or of building up a section which has to be partially assembled and partially riveted before the balance of the section can be put together and the piece finished. There is also a tendency to use an excessive number of rivets. A few excess shop rivets are not serious and do not appreciably increase costs unless the excess is great.

The contrary, however, is true in regard to field rivets, as we frequently find field rivets put in with a free hand, utterly regardless of what it will cost the erector to drive them. In one instance which occurs to me the designer insisted upon using 24 rivets to hold up one end of a 24-in. beam, which was not subject to any excessive load, and very carefully arranged the details so that 18 of these 24 rivets would be down in a pocket where it was impossible to properly back-up the rivet in driving.

Another case was the extension to a smokestack, where the new and old stacks were to be connected together by means of two angle rings. In arranging for this splice the new ring on the bottom of the new stack was carefully punched with holes every 6 in., evidently forgetful of the fact that the ring on the top of the old stack would have to be drilled by hand from a swinging boatswain's chair, and that every hole would probably cost at least $1. Holes spaced 2 to 3 ft. apart in that particular case would have been ample to have kept the two pieces of stack in line.

Another detail item that seems to receive little attention, outside of drawing rooms that are directly in charge of a shop superinendent, are changes in sizes of holes and in sizes of rivets. This is a frequent item of expense and a constant source of trouble, as unless everyone connected with a job is constantly on guard the condition will arise where a member that has been built using ¾-in. rivets will connect into a member that has been built using ⅞-in. rivets, and the holes for the field connections, instead of being the same size, will be of different sizes. In other words, of sizes suitable for the size of rivets used in the individual member.

It also pays well in arranging pitch lines and in spacing of rivets and of open holes to so arrange this spacing as to permit of the use of a rack punch or spacing table. For this purpose fine divisions in spacing should not be tolerated, and holes should be in line longitudinally, and the use of such a thing as an offset gage absolutely prohibited. Simplicity of detail will always tend toward low costs. In connection beams to girders or to columns it is always advisable to connect them either by the flanges or by the webs, whichever seems preferable, but it is never well to connect a beam by both flange and web, as bad holes are almost always the inevitable result, owing to the methods necessarily pursued in laying out the material.

Another item of similar character is the matter of gussets. Occasionally we see cases wherein the designer, in an effort to keep down his weights, has used a gusset so thin that he is afraid it is lacking in stability, and therefore reinforces the gusset by tacking on flats or angles to the edge, as stiffeners. This adds very materially to the costs, and could readily be avoided by making the gusset a trifle thicker. In many cases an increase in the thickness of a gusset of 1/16 in. would remove any reasonable doubt of its stability and would eliminate any supposed necessity for stiffening its edges.

Column splices constitute another item wherein much money is often uselessly spent. With the ordinary plate and angle columns there is not much need of any splices other than plates on the flanges. An attempt to splice the web also frequently results in bad holes and other difficulties, while a web splice arranged with angles generally serves no useful purpose other than covering up, possibly, a case of a poorly milled end.

Stiffeners on plate girders are often called for as being fitted at both ends. What useful purpose is accomplished by this fitting it is hard to see. For end bearings and intermediate concentrated loads it is of course necessary to have the end of the stiffener that receives the load properly fitted to the flanges, but aside from this there is little use in spending time and money in making a sung fit between the ends of stiffener angles and the flange angles.

Due attention is rarely given to the economies of duplication. To build one truss is expensive, but to build a large number of duplicate trusses is a relatively cheap operation, and it would frequently be economical to make a large number of parts of a structure exact duplicates, even though it involved more material than it would to make each separate and individual truss or part specifically designed for its work.

METHOD OF NUMBERING COUNTY BRIDGES AND CULVERTS.

Stencils are used by the officials of Hardin County, Iowa, for numbering concrete bridges and culverts. The foreman of each bridge and culvert crew is furnished with a set of number stencils. After the bridge or culvert is completed and before the concrete takes its initial set, the stencils for the proper numbers are pressed into some conspicuous portion of the concrete body. The cut illustrates the top of the parapet wall on culvert No. 2180. As a result of this system of numbering culverts and bridges soon take on a distinctive individuality and become familiar by number to both people who use the road and the road working crews and foremen. This type of numbering will not be washed off by the rain, is sightly and does not disfigure or mar the appearance of a bridge as does the crudely scratched numbers in use in some counties.

Method of Numbering Culvert.

THE NEW $2,500,000 COAL PIER OF THE B. & O. R. R. AT BALTIMORE, MD.

A coal pier stated to be the first of its type ever built and believed to be the largest in the world, was formally opened a few days ago. This was the new export pier of the Baltimore & Ohio R. R. at Curtis Bay, Baltimore Harbor. It has a capacity of 12,000,000 tons a year or a maximum capacity of 7,000 tons an hour, is of concrete and steel construction and is electrically operated.

The pier is a new departure in the construction of such facilities, being designed to overcome breakage while materially increasing the speed at which vessels may be loaded. With its system of car unloaders, belts and towers, it is possible to work on four vessels with cargo coal and bunker fuel at the same time.

The pier consists of two car dumpers at the land end, and a concrete deck 8 ft. above mean tide. On this deck are four loading towers and two trimming towers to which coal is delivered by belt conveyors from receiving hoppers at the car dumpers or from the balancing bin interposed between the dumpers and the pier. The pier is in two units, a car dumper, two loading towers and a trimming tower comprising a unit. Each dumper handles 60 50-ton cars or 40 100-ton cars an hour. The pier will handle a car 54 ft. in length.

The tracks leading to the dumpers are on a descending grade, cars running to the barney pit by gravity. The barney pushes the cars up a 10 per cent grade to the cradle of the car dumper. After the car is placed on the cradle it is clamped and turned upside down, delivering the contents to a counterweighted apron. The apron is raised when a car is being dumped in order to minimize breakage. After the car has been dumped the apron is lowered to permit the coal to slide freely to the belts that convey the coal to the vessel.

There are three belts to each car dumper, the belts being 60 in. in width, with a capacity of 2,000 tons an hour and running 500 ft. a minute. Two in each group run out on the pier to a loading tower. The third runs to the balancing bin.

The loading towers are equipped with a cage supporting a shuttle ram. The cage is raised or lowered to suit the height of the vessel being loaded, thus providing further precaution against breakage to the coal. The cage has a variation in height of 27 ft., the minimum height above the water being 15 ft. The shuttle ram, which can be run out on either side of the pier, has a maximum reach of 45 ft.

With the towers traveling along the pier in a horizontal direction and the shuttle working in and out at right angles to the direction of the towers, this apparatus will load a hatch uniformly and reduces trimming to a minimum.

The two trimming towers, located on either side of the pier, have belts 48 in. wide, with a capacity of 1,500 tons an hour when traveling at a speed of 500 ft. a minute. Coal for these belts is taken from the balancing bin. The towers have swinging booms 45 ft. long. They are attached at their base to turn-tables and can be moved in a circle on a horizontal plane. They have a vertical variation of 35° each way from the horizontal.

While the loading towers are working on the cargo the trimming towers are loading the bunker coal. After the loading towers have finished their work the trimming tower finishes the slow work on the vessel, thereby releasing the loading towers to work on another vessel.

The functions of the pier are interlocked and controlled electrically with push-buttons located every 20 ft. on each belt conveyor runway. By pushing a button all movable parts of the belt, tower and feeders are stopped.

The operators are located in houses on the shuttles. They first start the shuttle belt and when this is running at full speed the main belt automatically starts, and when at full speed the feeders also start automatically. The shuttle belt runs at greater speed than the main belt, the main belt running faster than the feeders, so there is no danger of flooding the main or shuttle belts. A master control of the pier is located in the superintendent's office, enabling him to establish the maximum speed at which the belts are run.

General View of 12,000,000-Ton Export Coal Pier of the Baltimore & Ohio R. R. at Curtis Bay Terminals, Baltimore, Md.

Another device to overcome breakage is a lowerator which will be attached when lump coal is being loaded. The lowerator deposits coal in the vessel with a drop of but 3 ft.

Two tracks leading to the car dumpers are covered by a steel and concrete thawing shed with a capacity of 22 cars, into which cars are placed in severe winter weather. Coal placed in this house where the temperature is kept at 180° for 30 minutes will thaw out sufficiently to free itself. Both the thawing shed and car dumpers are operated by steam.

In constructing the pier it was necessary to dredge a channel into the pier as well as the slip on each side. Four hundred and fifty thousand yards of sand and clay were dredged and used to build the receiving yard. This was done by suction dredge and pumped to a height of 30 ft.

The pier cost $2,500,000, and work on it was commenced in February, 1916.

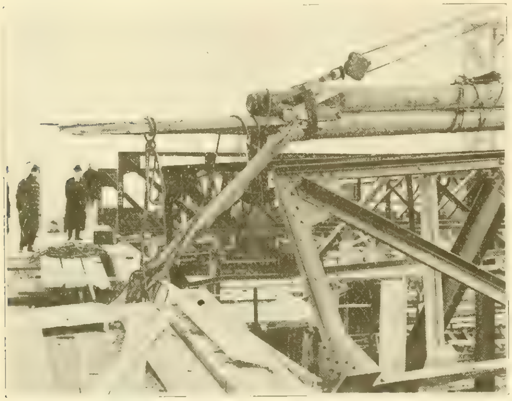
Protection of Steel Work from Locomotive Blasts.—Chilled cast iron plates make the best form of protection to steel work from locomotive blasts, according to the 1917 report of the Committee on Iron and Steel Structures of the American Railway Engineering Association. The plates should be placed directly over the tracks and have a width of not less than 30 in. They should be closely joined at their ends to prevent penetration of gases.

A DERRICK ACCIDENT AND ITS LESSONS.

Contributed by Henry Blood, Engineer, Bureau of Buildings, Portland, Ore.

On Jan. 31st the boom of a stiff-leg derrick used on the erection of the Public Auditorium in Portland, Ore., broke near the upper end and dropped a roof truss to the street. Two steel workers were riding to the roof on the truss; one fell with it and was killed; the other jumped or was shaken off inside the building and escaped serious injury. Three roof trusses besides the one that dropped, and several roof beams were damaged. The top of the wall was crushed for a short distance, and a section of scaffolding was destroyed. Broken pieces of wood from the end of the boom were found to be seriously affected by dry rot, although the outside appeared to be sound.

The derrick consisted of two stiff legs placed at right angles to each other, a mast approximately 30 ft. high, and a boom with a reach of 90 ft. The stiff legs, sills and mast were composed of square timbers about 12 in. x 12 in., the bottom of the stiff leg being about 32 ft. from the foot of the mast. One stiff-leg was placed north and south with the mast at the north end. The other stiff-leg ran east. The main boom was 70 ft. long and 15 in. or 16 in. in diameter at the larger end. It was spliced out to a length of 90 ft. by lapping another round timber about 40 ft. along the under side and lashing the two together with wire rope at the ends and center of lap. The contractor stated that this timber was 5 years old and that it had been stored in their open yard when not in use, where it was exposed to the weather. When new it had been given a coat of linseed oil and one of green paint. He thought that an outside examination would not have indicated unsoundness, and that the steelworkers would not have ridden on the truss if they had considered it unsafe.



Derrick Boom Accident Caused by Dry Rot.

There were two lifting blocks; one at the end of the main boom, and one at the end of the spliced length. They had a four-part steel cable, and the same line ran through both, so that the strain was divided about proportionately between them. The hoisting line ran from the lower hoisting block to a sheave close to the end of the boom, followed the top of the boom to the mast, and passed down through the turning pivot to the engine, which was located on the main floor of the Auditorium.

The boom was 10½ ft. in diameter at the tip; it had a vertical slot 2 in. wide and 13 in. long for the hoisting line sheave, a collar formed of two pieces of 1-in. x 6-in. metal with 1¼-in. bolts and heavy shackles for the hoisting and boom raising blocks. There was a ½-in. x 4-in. strap on each side hooked around the outer edge of the collar and extending back about 3 ft. Four ¾-in. bolts and an 1¼ sheave pin ran through both straps and the timber. There was an old horizontal check extending from the tip to a point beyond the inner bolt, and an old vertical crack running both ways from the sheave slot, which divided the end of the stick into four parts. There was also quite a large sound knot near the end. The break that caused the accident was close to the inner ¾-in. bolt.

The smaller roof trusses and beams were piled near the Third St. wall as delivered. A number had already been raised and set in place, some being as heavy or heavier than the truss, that was dropped, which weighs 5,100 lb. The wall is 60 ft. high at the point of accident. The truss had been lifted some distance above the wall and other roof framing, and turned at right angles to the wall. The boom was at an angle of nearly 45°. Two or three sharp reports like rifle shots were heard by bystanders a few seconds before the truss reached this position. They appeared to come from the end of the boom. The end suddenly snapped off 3 ft. from the tip, the truss dropped on the outer roof beam, slipped down across the wall and fell to the street, carrying away the scaffolding as it fell. The blocks and cable went with it, and some cable was reeled from the drum of the engine. The boom immediately dropped to the roof, striking transversely another boom that was lying over a truss, swung violently downward and split two or three large pieces from the end, one or two of which fell to the ground. Some electric wires on poles nearly as high as the wall were broken by the falling truss. The current was conducted to the roof steel and several workmen in contact with it received shocks. The 10-in. beam that was struck by the truss was sheared off diagonally through the web at that end.

An examination of the broken timber showed that it was so affected by dry rot near the end that probably not 25 per cent of the strength remained. Fungus growth was present in some of the splits. There was a thin shell of quite sound wood outside. Its condition could have been determined by boring a few small holes in it, or probably by percussion. It had very likely been strained to the breaking point by some previous load. The shape of the end connection and the fact that the spliced piece was not in line with the main boom would cause considerable eccentric stress when the boom was in its lower positions. The brake on the engine may have slipped and produced a shock on the cable; it was seen to slip a day or two later.

This adds to the lesson taught by a former accident on the Pittock Block, Portland, that derricks and other erection apparatus should be given more attention by their designers and by the contractors and city or state inspectors. The various parts should be strong enough to resist any probable combination of direct and secondary stresses that may come upon them in different positions with a reasonable factor of safety; and the timbers and cables should be carefully examined before use on each piece of work and at other regular intervals to see that they are in safe condition. Derrick timbers should not be left exposed to the weather for long periods when not in use; they are almost certain to be attacked by dry rot. Painting the outside may hasten and not prevent this.

Steel erectors should as far as possible keep the workmen from riding on loads, and they should be made more responsible by law for the proper construction, care and inspection of derricks and other erection equipment. This is not limited to steel structures, but applies to those of other materials; scaffolds on frame buildings are often built insecurely and sometimes cause accidents. Probably most accidents could be prevented by a little care and forethought. But it has generally been the practice to give consistent attention to the design and superintendence of permanent buildings, and none to the temporary structures used in their construction. It is not right to entirely slight the latter.

The Italian Government has granted to the Societa per le Forze Idrauliche della Silla a concession for the construction and working of water-power reservoirs in the upper valleys of the rivers Neto, Arno, and Ampollino. The total cost of the works to be established is estimated to amount to $13,510,000, and they must be completed within 15 years from the date of the concession.

METHOD OF PLACING SUB-AQUEOUS CONCRETE BY MEANS OF TREMIE.

In connection with the canalization of a portion of the Cape Fear River, North Carolina, by the Federal Government, two concrete locks were constructed. Owing to the character of the sub-foundations and other conditions, it was necessary to seal the bottoms of the lock cofferdams before pumping. The methods employed in this work are described by Capt. C. S. Ridley, Corps of Engineers, U. S. Army, in the January-February Professional Memoirs, from which the following notes are taken:

The cofferdam consisted of a single row of Lackawanna steel sheet piling anchored back to pine pile anchorages, except at the lower end, where "pocket" construction was used. It followed the outline of the lock and was generally within 18 in. of the base of the lock walls except at the ends, where the distance was increased to 5 ft.

It was decided: First, to splice the steel piling used in the cofferdam, so that the tops could be easily removed, thus leaving the bottom portions as a permanent cut-off wall around the lock foundation; second, to drive bearing piles over the entire area of the foundation; and third, to seal the bottom of the cofferdam with a layer of concrete 6 ft. thick deposited under water and enclosing the heads of the foundation piles.

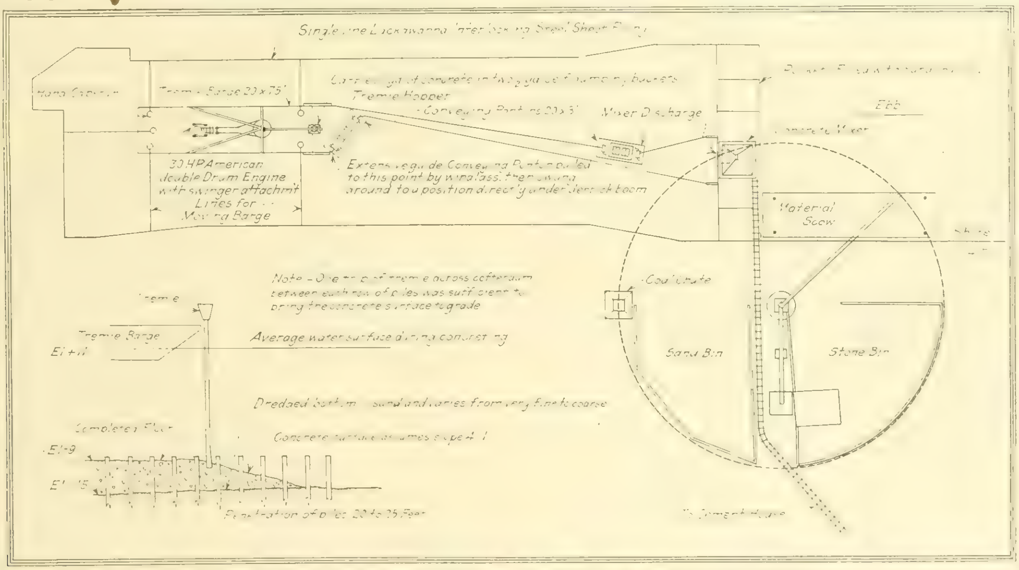

Single Line Lackawanna Interlocking Steel Sheet Piling
Hand Capstan
Tremie Barge 20x75'
Carrying 1 yd. of concrete in two ½ yd. self dumping buckets
Tremie Hopper
Conveying Pontons 20x3'
Mixer Discharge
Pocket Construction
Ebb
Concrete Mixer
30 HP American Double Drum Engine with swinger attachm't
Lines for Moving Barge
Extension guide Conveying Ponton pulled to this point by windlass, then swung around to a position directly under derrick boom
Material Scow
Shore
Coal Chute
Note - One trip of tremie across cofferdam between each row of piles was sufficient to bring the concrete surface to grade
Tremie
Tremie Barge
El +11
Average water surface during concreting
Sand Bin
Stone Bin
Dredged bottom - sand and varies from very fine to coarse
Completed Floor
Concrete surface assumes slope 4:1
El -9
El -15
Penetration of piles 20 to 25 Feet
To Cement House

Fig. 1—Plant Layout and Method of Construction of Concrete Lock Floor.

With a view to depositing the concrete in the foundation slab by means of a tremie, the foundation piles were driven in rows across the cofferdam, the successive rows being 4 ft. apart between centers. This piling was driven under water by means of extension leads and a follower. This left a free passage between each two rows of piles about 3 ft. wide. The bottom of the tremie was about 15 in. in diameter, thus leaving a clearance of about 10 in. on each side of the tremie.

The method of depositing the concrete is shown in Fig. 1. The progress of the work necessitated putting in the foundation concrete during the flood season of the year. As a consequence, the depth of water through which the concrete was deposited varied from 22 to 34 ft. All of the concrete was made at the mixing plant installed on one of the pockets at the lower end of the cofferdam. The mixer deposited directly into two ½-yd. self-dumping buckets on "conveying" pontons. There were two of these pontons and they were equipped with windlasses, one at each end, by means of which they were pulled to and from the tremie barge.

The tremie barge was an ordinary deck barge, 20x75 ft., at one end of which was installed a stiff-leg derrick with a 45-ft. boom. From one line of this derrick was suspended the tremie, and the boom was raised to such a height as to make the tube of the tremie pass close to the end of the barge. The concrete bucket line was run through the same boom at such a point that, when hanging vertical, the concrete bucket would be in position to dump into the hopper of the tremie. While concreting in the upper end of the coffer, it was necessary to lift the buckets from the pontons with a small unloading derrick at the downstream end of the barge and run it on cars to the upstream end to a point directly under the boom, where it was lifted up by the derrick engine and dumped directly into the tremie. After the work had progressed downstream the length of the tremie barge, the barge was turned around and thereafter the buckets were lifted directly from the barges to tremie by the same engine that handled the tremie.

The tremie consisted of a hopper, middle sections, and a bottom section bolted together through flanges. The middle sections were made of various lengths, so as to provide for different stages of water. These sections were cylindrical and were of a uniform diameter of 12 in. The bottom section was about 6 ft. long and was 12 in. in diameter at the top, but increased in diameter to 15 in. at the bottom. The middle sections were reinforced on the outside by angle irons to provide longitudinal stiffness.

In order that the floor might be as nearly monolithic as possible, it was planned to have the work go on continuously 24 hours per day. Stops were made for repairs and high water only. Delays for repairs were of but short duration.

Concreting was started at the upper end of the cofferdam and a layer of the full thickness of 6 ft. carried continuously to the lower end. After the full thickness had been obtained at the upper end between the first row of foundation piles and the cofferdam, the tremie was shifted to the second row and from this point on to the end one trip across the cofferdam between each two rows of piles was sufficient to bring it to grade. The concrete being deposited at the top of the slope, as shown in Fig. 1, flowed down the slope and thus distributed itself in sloping layers. In this way a long lap joint was secured instead of a short vertical joint and the various layers were more or less bonded together.

When first starting, the tremie was rested on the bottom and a batch of rather dry concrete dumped in. There was added also three or four sacks of cement. The tremie tube held something over ½-yd. of concrete, so that if the concrete was "washed" only a very small amount would be affected and, by the method of depositing, this would be spread out. The hopper of the tremie held ½ yd. The man at the hopper so managed that the top of the column of concrete was always visible near the top of the tube.

When the tremie is "charged," the concrete first poured into the tube is undoubtedly more or less "washed," and between ½ and 1 yd. of concrete is thus affected. If the concreting is carried on continuously, however, and the tremie is carefully handled, there is little need for starting "charges." With the method of depositing, as described above, and washed concrete, except at the extreme upper end of the coffer, would be disclosed at the top of the slab and would be spread out somewhat. It would be discovered with the pick when cleaning off for the lock walls and be removed.

With the tremie resting on the bottom, or in concrete just deposited, and the tube full of concrete and all water excluded, the following operations were carried out: A ½-yd. bucket of concrete was dumped in the hopper, usually filling it. The man at the hopper then signalled the engineman to hoist the tube slightly. This would cause the concrete to run out until the hopper was emptied when, by slacking off on the hoisting line, the movement of concrete was stopped at once. This operation required skill and care, as the tremie must be raised only by a very slight amount, when the pressure of the column of concrete is sufficient to force itself out at the bottom. To move laterally, the engineman moved the boom supporting the tremie, thus dragging the bottom of the tremie through the concrete. When this method brought the tremie to the side of the barge, the tremie was held in place while the barge was shifted laterally its full width. In practice, when the full thickness had been secured at one end of the cofferdam, the concrete was deposited by simply shifting the tremie or by a simultaneous combination of a slight lifting and shifting. As soon as shifting started, the concrete began to run out and when the hopper was empty the shifting stopped until another half-yard was dumped into the hopper. Thus the tube was kept full of concrete at all times and, being water-tight, the concrete reached the bottom in its original state. In all 4,327 yd. of concrete was deposited in the foundation under water. This concrete was a 1:2:4 mixture, and was made rather wet to facilitate the flow through the tremie.

The operation of the tremie offered no special difficulties, with the exception of that due to interference with the foundation piles. These piles were driven under water with a follower and, of course, were not perfectly lined up, so that in some cases there was not sufficient space for the tremie. When such conditions arose, it was usually possible to work around it, but sometimes the tremie "charge" would be lost.

When a "charge" is lost, the concrete flows out of the tube very rapidly and the water rushes in at the bottom and fills the tube. A part of the charge lost is thereby "washed" and rendered useless. It is believed, however, that only that part is washed which is immediately under and near the bottom of the tube. When the concrete flows out, it forms a mound spreading out from the bottom of the tube as a center. When the concrete is nearly all out, the water rushes in and this rapidly flowing water washes a small amount of the concrete just below and adjacent to the bottom of the tube. The flow of water is probably strong enough to carry some of the particles of concrete back up into the tube and wash them thoroughly and, when the movement stops, they settle back on the top of the mound of concrete. It is thought that the greater part of the concrete is not washed nor injured to any great extent while it is flowing from the tube. This theory is borne out by the fact that after the cofferdam at Browns Landing was pumped out, the locations of some of the lost charges were disclosed as mounds. When one of these mounds is attacked with a pick, the center is found to contain loose rock and sand covered over with a thin layer of imperfectly set cement. This center, when removed, leaves a small crater surrounded by a rim of perfectly hard and homogeneous concrete.

On account of floods, the coffer was not pumped out as soon as expected and as a result the concrete was about two months old when first exposed. The top of the concrete was found to be covered with about 5 or 6 in. of mud, which had settled to the bottom. Underneath the mud was a thin coating consisting of a mixture of imperfectly set cement and mud. This coating averaged probably ½ in. thick over the whole surface, although it was thicker in the low places. Underneath this scale in the depressions, there was usually found a little loose sand and rock, although in places the scale was directly over the concrete.

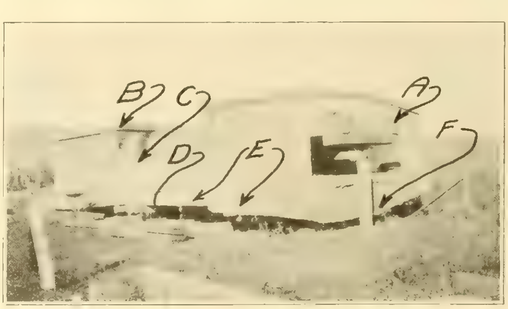
On removing the scale and loose rock the surface concrete, for an average depth of 3 or 4 in. over the whole area probably, appeared to be a lean mixture and could be removed without great difficulty with a pick. In one or two places pockets of this weak concrete, as much as 18 in. deep and 4 or 5 ft. square, were found, but this was exceptional. Before building the lock walls, this was thoroughly removed, under the base of the walls, by picking and the concrete underneath was found to be extremely hard and homogeneous.

The general level of the surface was good, the maximum difference in elevation between the top of the mounds and the bottom of the depressions being probably 18 in. It was satisfactory in every way as a foundation for the construction of the lock walls.

METHOD OF RAISING AND MOVING 70-TON CONCRETE CULVERT.

A reinforced concrete box culvert in Shelby County, Iowa, was moved recently to a new location about ¼ mile distant from its first installation. The culvert is 6 ft. by 4 ft., 24 ft. in length, with straight wings and coping. It contains 34.55 cu. yd. of concrete, 1983 lb. of reinforcing steel and weighs approximately 70 tons.

To raise the box from its former site required four 8x16's, 32 ft. long. These were placed lengthwise through the barrel of the culvert. Then to keep the top from lifting off five sets of 8x12's, shown as B, bolted together with long 1-in. bolts, shown as C, were used. It required 24 20-ton housemovers' screw jacks, shown as D, to start the culvert from its resting place. After it was once started it jacked up much easier. The footings, shown as E, for this particular culvert, are 2 ft. 8 in. wide by 2 ft. deep on the barrel, and 2 ft. 11 in. wide by 2 ft. deep on the wings. The curtain wall, shown as F, made standard on all the culverts, is 9 in. wide and 1 ft. below the bottom of the footings.



Reinforced Concrete Box Culvert Being Moved to New Site.

The culvert came out of the ground in fine shape, without a crack. It was moved to its new site on rollers, being pulled by means of a capstan and horses. The picture shows it moved about 100 ft. from its former location. F. W. Sarvis is engineer of Shelby County.

BRIDGE IMPACT TESTS WITH ELECTRIC LOCOMOTIVES.

During the summer of 1916 a series of tests were conducted on the Norfolk & Western Ry., near Bluefield, W. Va., the particular purpose being to compare the effect of the electric locomotives used by the N. & W. Ry. in that locality with the effect of the Consolidation and Mallet types of steam locomotives. Few results of the tests were given in the report of the Committee of Iron and Steel Structures of the American Railway Engineering Association, submitted last week at the 18th annual convention of the association. The report is printed in full in the March Bulletin of the association, from which the following has been abstracted:

All of the structures tested were short-span bridges of the following types and dimensions—center to center of bearings: No. 867, 39-ft. through girder; No. 880, 65-ft. through girder; No. 835, 84-ft. through girder; No. 836, 85-ft. through girder; No. 844, 96-ft. through girder.

All bridges were plate-girder spans, with the exception of No. 836, which consisted of plate girders under the eastbound track and riveted trusses under the westbound track.

The test loads used in the experiments consisted of: (a) The standard electric locomotive used by this company, consisting of two similar units coupled together. This locomotive was generally followed by a caboose, but the locomotive itself was of sufficient length to cover the structure. (b) The ordinary type of consolidation locomotive, followed by caboose. (c) The Mallet type of locomotive, followed by caboose. (d) Loaded 90-ton coal cars of the Norfolk & Western standard type. These cars were drawn, in some cases, by an electric locomotive and in other cases by a steam locomotive, but the data reported herein as relating to carloads refer only to the effect of the cars and not to the locomotive.

The electric locomotive used by the Norfolk & Western Ry. Co. has crank connections between the motors and the driving wheels, and the driving wheels are connected by means of side rods. Each unit has two motors and two sets of drivers independently connected. As a result of this arrangement, the relative position of cranks and side rods for the two sets of drivers is not fixed and may vary through all possible angles.

In the case of the Mallet locomotive the two sets of drivers are also independent in action, and the relative position of the side rods and counterweights may vary through all possible angles.

The special test train was run over the structure a number of times at various rates of speed. The first movements were made at a low speed of 8 to 10 miles per hour, so as to secure readings not affected by impact.

Having made two or three slow runs, the speed of the train was gradually increased to the maximum practicable speed, a number of movements being made at the highest speed. In the case of electric locomotives the speed was limited to about 28 or 29 miles per hour, by reason of the character of the motors. In the case of steam locomotives the speed was made as high as practicable, considering safe operation and capacity of the locomotive. On account of the limitation of speed of the electric locomotive to 28 or 29 miles per hour, a special effort was made to secure results from the steam locomotives at about the same speed, as well as at higher speeds.

In the case of a steam locomotive the rotating parts are not balanced, the counterweights having a weight in excess of the amount necessary to balance the wheels with respect to rotation. The effect of this unbalanced condition of locomotive drivers is to cause the pressure upon the rail to vary considerably from the static pressure, such variation being equal to the centrifugal force of the unbalanced weight. When a locomotive crosses a bridge at just the right speed the impulses thus produced by the unbalanced drivers will produce a certain amount of vibration in the structure, which is the chief source of impact. If these impulses are timed so as to correspond to the natural period of vibration of the loaded structure, then the effect will be cumulative, and the vibration or impact will be a maximum. The speed of the locomotive which brings about this synchronism of action is called the **critical speed** of the locomotive. In the tests in question it was found that the critical speed for the consolidation locomotive varied from about 45 miles per hour for the shortest span to about 33 miles per hour for the longest span. The critical speed for the Mallet locomotive was presumably the same, since the diameters of the drivers were the same; but on account of the variation in relative position of the counterweights in the two sets of drivers of the Mallet locomotive the critical speed was not so readily determined. In the case of both of the steam locomotives a considerable number of tests were made at or near the critical speeds, so as to secure maximum results. In all, 315 runs were made.

TABLE I—SUMMARY OF MAXIMUM IMPACT VALUES.

Bridge number.	Elec. Loco. at 28-29 mi. hr.	Consol. Loco. At 28-30 mi. hr.	Consol. Loco. At Critical or Max.	Mallet Loco. at Crit. or Max. L = 0°-20°.	Mallet Loco. at Crit. or Max. L = 90°+.	Mallet Loco. at Crit. or Max. L = 160°-180°.	Cars.
Maximum from Deflectometer.							
867 (39 ft.)	15	..	15	26	19	9.5	..
880 (65 ft.)	13	16	16	38	8	8	..
835 (84 ft.)	8	9	29	..	..	..	..
836 (84.5 ft.)—							
Girders	14	23	40	33	15	8	20
Trusses	14	10	15	..	..	..	26
844 (96.5 ft.)	2	..	15	31	12	11	9.5
Averages	11	14.5	20	32	13.5	8.5	18
Average of Extensometer Maxima.							
867 (39 ft.)	15	..	16	26	26*	16	..
880 (65 ft.)	14	12	21	33	13	13	..
835 (84 ft.)	7	6	21	..	..	..	..
836 (84.5 ft.)—							
Girders	14	27	53	37	24	16	14
Trusses	16	12	25	..	..	..	16
844 (96.5 ft.)	11	..	21	40	18	8.5	12.5
Averages	13	14	26	34	20	13	14

*45°.

In the case of the Mallet locomotive a record was made of the approximate relative position of the two sets of counterweights or side rods. This was not determined with great accuracy, but it was found that by giving careful attention to the movement of the side rods a fairly accurate estimate could be made. This was rather easy to do when the angle between positions was close to zero, or 180°. Owing to slip of drivers in starting and stopping, the relative position of the two sets of counterweights would change quite rapidly during a series of runs.

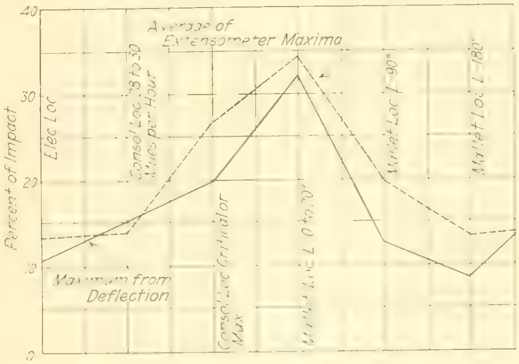


Fig. 1—Summary of Maximum Impact Values.

The effects of the different test loads can be best studied by means of the averages given in Table I. These averages are plotted in Fig. 1, so as to bring out the results more clearly. The diagram shows that the extensometer results follow the deflectometer results quite closely, being in most cases somewhat higher. The electric locomotive produces an impact of 12 to 14 per cent. The consolidation locomotive, at the same speed as the electric locomotive, gives about 15 per cent, at its critical or maximum speed an impact of from 20 to 25 per cent. The impact from a Mallet locomotive depends very largely upon the relative positions of the counterweights. Where the two sets of counterweights synchronize the impact is relatively very large, being about 32 to 34 per cent. Where the angle of relative position is about 90° the impact is 15 to 20 per cent, and where this angle is 180° it is but little more than 10 per cent. The impact from loaded cars is from 15 to 18 per cent, somewhat higher than from the electric locomotive.

The results from electric locomotives are, it is believed, somewhat higher than they would be with a well-balanced machine. Some of the impact is, of course, due to vibrations caused by roughness of wheel and rail, but the experience of the committee would indicate that the results obtained are larger than would be produced by these causes. Information was secured relative to the actual weights of side rods and counterweights from two of the electric locomotives. From this information it is found that the additional load due to centrifugal force at 28 miles per hour amounted to about 1.8 per cent of the weight on drivers in one case and 3.5 in the other. This is not a large amount, and yet, taking into account the cumulative effect on spans more than 50 feet long, it might readily account for as much as 5 per cent of the impact, or at least half of the amount determined. In the work done by one of the members of the committee in 1898, and reported in Transactions of the American Society of Civil Engineers, Vol. 41, page 435, it was found that some of the locomotives there used were out of balance to a sufficient extent to produce a centrifugal force at 40 miles per hour, ranging from 12 to 19 per cent of the weight on drivers. These same locomotives produced impact effects on plate girders of as much as 30 per cent at speeds of 40 miles per hour or less. The electric locomotives under consideration appear to be out of balance to an extent of from one-third to one-half as much as the steam locomotives in question, and therefore it would seem reasonable to expect an impact effect from electric locomotives at 28 miles per hour of from 5 to 7 per cent, due to the counterweights alone. Tests made some years ago with an electric locomotive at Schenectady, N. Y., indicated a smaller effect than obtained in these tests. This is probably due to a better balanced condition of the locomotive. If an electric locomotive is perfectly balanced there should, theoretically, be no impact due to vibration, but a slight impact (perhaps 2 or 3 per cent in case of short spans), due to the rapid application of the load. The impact from the consolidation locomotive at its critical speed was rather less than has been obtained from earlier tests, but there is no special reason why the results from earlier tests with this type of locomotive should not be assumed as safe and proper values to use.

The results from the Mallet locomotive were the most interesting and instructive of all the tests. The effect of relative position of counterweights is very marked, and is what theory would call for. When the two sets of counterweights act together the effect is, of course, a maximum, in this case considerably greater than that from the consolidation locomotive. When the two sets act in opposite directions the impact is even less than that produced by the electric locomotive, indicating that with well-balanced parts both the steam and electric locomotive will produce very small impact. These results are also similar to those obtained previously with balanced compound locomotives.

The effect of loaded cars at a speed of about 28 or 29 miles per hour was considerable, amounting to 15 per cent or more. This rather high result was caused by some condition of wheel or axle which caused the car to vibrate on its springs. Such action of freight cars is often noticeable, and, from observations by members of the committee, the vibration corresponds in period to the rotation of the car wheel. In two or three cases, in former tests, the committee has observed a relatively high impact from this cause, but no such effect has been observed from passenger equipment.

DESIGN OF SMOOTH SHELL REINFORCED CONCRETE DOMES.*

The smooth shell dome may be in the form of any surface of revolution with its axis vertical. The stresses in the spherical or conical dome shell of uniform thickness may easily be determined analytically but shells of other forms or of varying thickness can best be analyzed graphically. An exact analysis of the smooth dome shell has not yet been made but the very simple method given below will give the stresses accurately enough for all practical purposes. The assumption is made that the shell is very thin so that all internal forces act in and tangential to the surface midway between the outer surfaces of the dome shell. It follows from this assumption that secondary flexual stresses due to the distortion of the dome under load are neglected, but for ordinary cases their effect is very slight. The stresses consist of compression along the meridians and either compression or tension along the horizontal circles.

When the load is uniformly distributed on each horizontal ring around the dome, the stresses are also uniform in every ring and there are no diagonal shearing stresses. When the dome is eccentrically loaded the stresses are indeterminate and diagonal shears exist. The meridianal and ring stresses are smaller under partial load than they are under full load. From comparison with the Schwedler dome under eccentric load it appears that the diagonal shears must be comparatively small and are adequately provided for in the case of wind and uneven snow load. Of course a heavy concentrated load would have a punching effect and would also produce local flexure to an indeterminate degree.

The writer's treatment of the spherical dome given below is somewhat similar to that given in "Handbuch fur Eisenbetonbau" by von Emperger, Band IV, Teil I, z. 546 and also that of E. Schmitt, Trans., A. S. C. E., Vol 52, page 262, and W. Cain, Trans., A. S. C. E., Vol 55, page 201.

Dead Load Stresses in Spherical Dome of Uniform Thickness.—Case 1. Closed at crown. See Fig. 1.

R = radius of sphere
t = thickness of shell.
g = unit weight of material of dome.
T = unit meridianal stress at any height.
C = unit stress in any horizontal ring.
B = total stress in skewback ring.
c = the ratio h/R.
W = total weight of dome above any ring.

From Geometry, area of surface $= 2\pi R h$.

Hence $W = 2\pi R h g t$.

Treating the whole shell above any ring as a free body

Total meridianal thrust $= W/\sin a = WR/r$.

The unit meridianal thrust is equal to the total thrust divided by the area $2\pi r t$,

or $$T = \frac{-WR}{2\pi r^2 t} = \frac{-2\pi R^2 hgt}{2\pi r^2 t} = \frac{-R^2 h g}{2Rh - h^2}$$

hence $$T = -Rg \cdot \frac{1}{2-c} \quad \text{(Eq. 1.)}$$

In order that no horizontal thrust will be exerted on the supports of the dome a skewback tension ring is usually placed at the foot of the dome. The stress, B, in this ring will now be found.

Total horizontal thrust $= W \cot a$.

The thrust per unit of length of circumference at the base is

$W \cot a/2\pi r$ and the ring stress B is
$r \times (W \cot a/2\pi r) = W \cot a/2\pi$.

Therefore $$B = \frac{2\pi R h g t}{2\pi} \times \frac{R - h}{\sqrt{2Rh - h^2}}$$

$$B = R^2 gt\,(c - c^2)\sin a \quad \text{(Eq. 2.)}$$

The circumferential ring stresses act horizontally tangent to the mid-surface of the dome shell. Consider a plane to be passed through the vertical axis of the dome and the half of the shell above any horizontal circle to be a free body. Suppose the dome below this section to be replaced by a skewback ring. Then the only horizontal forces acting on the half of the dome are the circumferential stresses in the shell acting on the section cut and the stress in the ring at the base and these must be equal and opposite. The base ring stress is therefore equal to the integral of the circumferential stress in the shell on one side of the center of the dome.

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*From an article by C. S. Whitney in the December Cornell Civil Engineer.

Then $dB = C\,dA = [illegible]\,C\,t\,R\,da$ (See Fig. 1.)

or $C = \frac{-1}{tR}\ \frac{dB}{da}$

$B = R^2\,gt\,(1 - \cos a)\cot a$;

$C = -d\,[R\,g\,(1 - \cos a)\cot a]\,da$

$= \frac{-R^2 g}{2R - h} - g\,(R - h)$

$C = -Rg\,(1 - c - \frac{1}{2 - c})$ .... (Eq. 3.)

From the preceding formulæ it will be noted that the stresses in the shell are independent of the thickness of the shell for the assumed conditions and hence the dome may be made as thin as practical construction will permit if only the dead weight of the shell itself is to be supported. If the dome is to be designed for an additional dead or live load uniformly distributed over the surface, the value of "g," the heaviness of the material of which the shell is constructed, may be increased in proportion to the increase in the total load.

The circumferential ring stress is equal to —½ R g (compression) at the top and decreases to zero when h is about .385 R. Below this "zone of rupture" the circumferential stress is tensile and steel must be introduced to resist the tension unless provision is otherwise made for it in the masonry. The skewback ring stress is a function of the total weight of the dome and the superimposed loads.

Case II. Lantern and open at crown. See Fig. 1.
W_1 = weight of lantern.
$2\,\pi$ Ragt = weight of shell removed.
b = radius of lantern ring.
B_L = total stress in lantern ring.

The stresses are found in the same manner as in the preceding case. Total weight = $W + 2\,\pi\,R\,(h - a)\,g\,t$.

$$T = -\frac{[W + 2\,\pi\,R\,(h - a)\,gt]\,R}{2\,\pi\,r^2 t}$$

From which

$$T = -\frac{W - 2\,\pi\,R\,a\,g\,t}{2\,\pi\,Rt\,(2c - c^2)} - \frac{Rg}{2 - c}$$

Also $B = \frac{\cot a}{2\,\pi}\,[W + 2\,\pi\,R\,(h - a)\,gt]$ .... (Eq. 4.)

or $B = \frac{W - 2\,\pi\,Ragt}{2\,\pi}\ \frac{1 - c}{\sin a} + \frac{R^2 gt\,(c - c^2)}{\sin a}$ .... (Eq. 5.)

As before $C = -\frac{1}{tR}\cdot\frac{dB}{da}$

$C = -\left(\frac{W - 2\,\pi\,Ragt}{2\,\pi\,tR}\right)\frac{d\cot a}{da} - \frac{d\,(gh\cot a)}{da}$

$= \frac{W - 2\,\pi\,Ragt}{2\,\pi\,tR}\csc^2 a - Rg\,(1 - c)\ [illegible]$

$C = \frac{W - 2\,\pi\,Ragt}{2\pi\,t\,R}\ \frac{1}{2c - c^2} - Rg\,(1 - c - \frac{1}{2 - c})$ .... (Eq. 6.)

The compression in the crown ring

$B_L = -W_L\,\frac{R - a}{b}\ \frac{1}{2\,\pi} = -W\,\frac{R - a}{2\,\pi\,b}$ .... (Eq. 7.)

From Equations 4 to 7 the influence of the addition of a lantern to the dome may be determined. If the weight of the lantern is greater than the weight of the dome shell removed at the crown, the meridianal compression is increased and the horizontal ring tension is increased so that the zone of rupture is raised. If the lantern is too heavy the tension may enter the crown ring.

The stresses produced by a live load of p pounds per square foot of horizontal projection of dome surface are found in the same way and are given by the following formulæ:

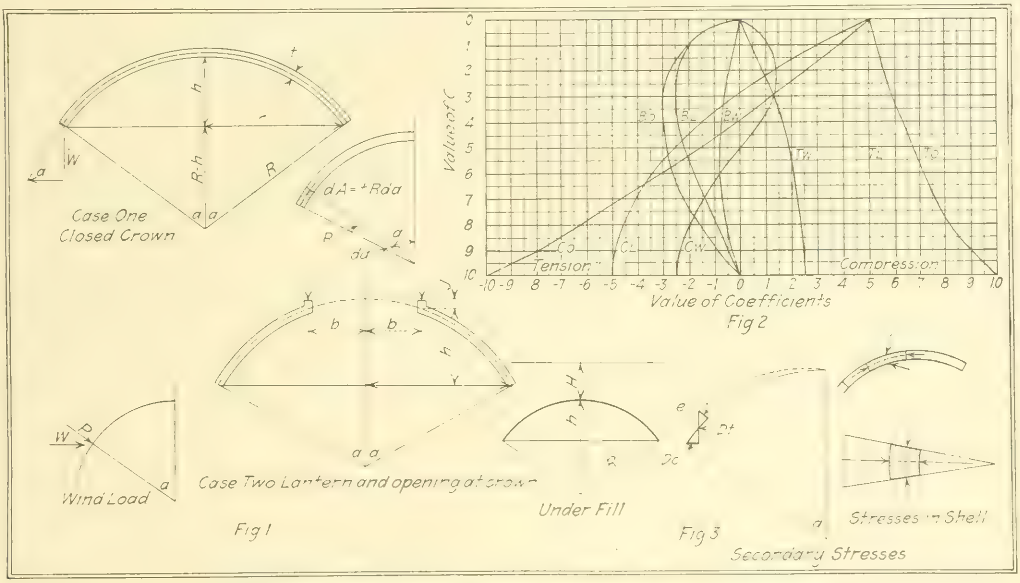
$W_w = \pi\,r^2\,p$

$T = \frac{pR}{2t}$ .... (Eq. 8.)

$C = \frac{pR}{2t}\,(1 - 4c + 2c^2)$ .... (Eq. 9.)

$B = \frac{pR^2}{2t}\sin a\ (1 - c)$ .... (Eq. 10.)

The wind stresses produced by the vertical components of a wind load equally distributed on each ring according to the relation $p = w\sin^2 a$ are given by the following formulæ taken from the Handbuch fur Eisenbetonbau:



Figs. 1-3—Methods for Design of Smooth Shell Reinforced Concrete Domes.

$T = \frac{Rw\,\sin^2 a}{t\ \ 4}$ .... (Eq. 11.)

$C = \frac{Rw\,\sin^2 a}{t\ \ 4}\,([illegible] - 4\sin^2 a)$ .... (Eq. 12.)

$B = Rw\,\frac{\cos a\,\sin^3 a}{4}$ .... (Eq. 13.)

This distribution of wind load has the effect of lowering the zone of rupture and producing very low stresses in the crown. It has therefore a much less critical effect than a uniform distribution on the horizontal projection and hence it seems advisable to use the latter in preference to the former. It may be noticed that Equations 8 to 13 apply to spherical domes whether the shell has a uniform thickness or not.

On the curve sheet Figure 2 are plotted the variable coefficients in Equations 1 to 3 and 8 to 13 and these curves may be used for the preliminary design of spherical domes. Using the coefficients given by these curves, for any value of h/R, or c, the stresses are given by the following equations:

[illegible]

[illegible]

WIND LOAD.

$$T = Tw\,Rw/t \qquad (11')$$
$$C = Cw\,Rw/t \qquad (12')$$
$$B = Bw\,R^2w \qquad (13')$$

An interesting case given in the Handbuch fur Eisenbetonbau is that of a horizontal earth fill over a spherical dome. The stresses produced by the vertical weight of the earth the heaviness of which is y pounds per unit volume are given by the following formulæ: (See Figure 3.)

$$T = \frac{yR}{(2R - h)\,t}\left[HR + \frac{h}{2}(R - H) - \frac{h^2}{3}\right]$$

$$C = \frac{y}{Rt\,(2R - h)}\left[-h^4 + h^3(4R - H) - Rh^2\left(\frac{14}{3}R - 4H\right) + \frac{R^2h}{2}(3R - 9H) + HR^3\right]$$

The value t is the thickness of the dome at the zone where the stresses are being determined and hence the formulæ apply to spherical domes of variable thickness as well as to those of uniform thickness.

Secondary Stresses.—In order to determine the importance of flexural stresses due to the dead weight of smooth shell spherical domes of uniform thickness, the writer made the following approximate analysis of the bending along the meridians. The assumptions are made that the deformations are caused only by the meridianal thrust and the horizontal ring stresses as given by the theoretical formulæ previously derived and that the bending moment in a meridianal section follows the law $M = EI\frac{d^2e}{ds^2}$ as in the case of a beam, e being the ordinate of the elastic curve of the meridian. Flexural stresses produce bending and conversely bending must produce flexural stresses.

Assuming the center of the crown to be stationary and the dome at first to be under no load, when the dead load is applied there will be a meridianal motion Dt of every point due to the thrust and a horizontal motion Dc due to the ring stress. See Fig. 3.

Poisson's ratio is about 0.1 for concrete and it will be placed equal to zero to simplify the problem.

$$\text{Then } Dt = \int \frac{T}{E}\,ds = \frac{gR^2}{E}\int_0^a \frac{1 - \cos a}{\sin a}$$
$$= \frac{gR^2}{E}\,ds\,(\cot a \csc a - \cot^2 a)$$
$$Dc = \frac{R \sin a\, C}{E}$$
$$= \frac{R^2g}{E}(\csc a - \cot a - \sin a \cos a)$$
$$\theta = \frac{Dt \cos a - Dc}{\sin a}$$
$$= \frac{R^2g}{E}(\cot a \csc a - \cot^2 a - \csc^2 a + \cot a \csc a - \cos a)$$
$$= -\frac{R^2g}{E}(1 - \cos a)$$
$$M = EI\frac{d^2e}{ds^2} = \frac{EI}{R^2}\frac{d^2e}{da^2} = Ig \cos a$$
$$s = \frac{Mt}{2I} = \frac{tIg \cos a}{2I} = (tg \cos a)/2$$

The flexural stress, s, is thus found to be very small and, although this derivation is not exact, it should serve as an indication of the magnitude of such stress. It indicates that the secondary stress may be neglected without appreciable error.

For domes which are not spherical or domes of variable thickness the graphical method of determining the dead load stresses will usually be found simpler than the analytical method. A graphical analysis accurate enough for practical purposes can easily be made for any smooth shell dome. Since the stresses are uniform throughout each ring only one sector cut out by meridianal planes need be considered. Let this sector be cut into blocks by the horizontal circles and consider the weight of each block as acting vertically at the center of gravity of the block. The meridianal forces may then be assumed to act between these centers of gravity. The radial component of the two circumferential forces acting on the sides of the blocks furnish the horizontal force required to hold the vertical loads and the meridianal thrusts in equilibrium. The forces are found by a stress diagram similar to that used for the Schwedler dome.

The stresses in the shell may then be found by dividing the forces acting on the sides of the block by the area of the corresponding sides. See Fig. 3. The accuracy depends on the size of the blocks and the central angle of the sector so they should not be made too large. For the spherical dome the area of the surface of the blocks may be made equal by spacing the dividing rings equal vertical distances apart and the weights of the blocks are then proportional to their thickness.

The dead load stresses in spherical dome shells of uniform thickness are independent of the thickness of the shell. It is, therefore, this influence of the load superimposed upon the dome which largely determines its thickness. The thickness is usually increased from crown to foot in order to secure a more uniform distribution of stress.

Wind and snow loads may best be provided for by assuming a uniform distribution on the horizontal projection. The limits of the position of the zone of rupture for the different conditions of loading must be located and steel placed in the concrete to take all tension which may occur in the horizontal rings. Light reinforcement should also be placed in a meridianal direction to provide for minor secondary stresses.

The thinness of the dome shell is usually limited by practical considerations so that the stresses in the concrete are not critical but provision must always be made to resist the tension in the shell and the horizontal thrust at the base.

A light system of construction suitable for large domes consists of a framework of meridianal and circumferential steel tees or angles designed to take the total tension and compression around which concrete is placed making the structure rigid. The steel frame is first erected and the forms for the concrete slab are wired to it. The dome of the Armeemuseum in Munich is of this type with a span of over 54 ft. and a thickness of 2.36 in. just below the lantern and 3.15 in. at the foot.

The reinforced concrete dome of the Nassau County Court House is about 24 ft. in diameter and has a uniform thickness of 3 in. That of the Temple Adath Israel, Boston, is 52 ft., 9 in. in diameter with a thickness of 3 in. at the crown and 5 in. at the base. While reinforced concrete is an ideal material for domes it has not been used so very extensively in this country because of the difficulty of form construction. It is interesting to note that in the large group of reinforced concrete buildings now under construction for the Massachusetts Institute of Technology the only structural steel used is for the framing of the dome over the central building. Many domes of over 70 ft. diameter have been built in Europe.

The forms and falsework required in the construction of concrete domes are very expensive when the ordinary method is used but R. Guastavino very ingeniously solved the problem of economical construction of tile domes by building them so that they are self supporting during construction. The domes are made of several courses of thin tile set in hard quick-setting mortar and by properly selecting the material and employing skilled labor, very thin, large diameter domes are built. The temporary dome over the crossing of the Cathedral of St. John the Divine in New York is a spherical tile dome of about 66 ft. radius with a span of 98 ft. and varies in thickness from 7½ in. at the foot to 3¾ in. at the crown. The average weight of the dome is 50 lb. per square foot.

This method of building domes in complete rings from the base up so as to be self-supporting could also be applied to reinforced concrete construction. The concrete could be laid in rings 5 or 6 ft. wide on forms hung from cantilevers on the scaffold built on the completed dome. The greatest difficulty would be in the delay caused by the setting of the concrete. Since the concrete in domes is usually not highly stressed it might be possible to hasten the set without seriously injuring the concrete.

PRACTICE AND EXPERIENCE OF STATE HARBOR COMMISSIONERS, SAN FRANCISCO, WITH CONCRETE WHARF SUPPORTS.

The present practice of the Board of State Harbor Commissioners, San Francisco, Cal., calls for the use of concrete for wharf foundations wherever the conditions permit. The methods and experience of the Commissioners in this work were set forth by Mr. Thomas S. Williams in a paper presented at the 5th annual convention of the American Association of Port Authorities. The notes that follow are taken from the Williams paper.

Concrete supports, used in the piers, wharves or seawall, have been of two main types, called cylinders and pre-moulded piles. Pre-moulded concrete piles were first driven in that harbor in 1911, for work close in shore, but emboldened by apparent success their use was extended until a new pier just completed, 200 ft. wide and 900 ft. long, is entirely supported by concrete driven piles.

The first piles used were 66 ft. long. 16 in. square, and were employed to sustain concrete masses under ferry aprons. In a pier just completed the length of piles varies from about 40 to 106 ft., and they were placed with centers 11x12 ft. apart.

The pile is reinforced with longitudinal steel rods, four of them, each ⅝ in. square, being set in piles 16 in. square and from 35 to 40 ft. long, and eight rods each 1 in. square in piles 20 in. square and from 90 to 100 ft. long. In order to facilitate driving, the piles are given a taper, beginning about 10 ft. from the point, tapering to 10 in. square. In setting the reinforcement, soft steel wire, ¼ in. in diameter, is wound spirally around the rods, with spacing for the wire of about 6 in. One of these piles, 20 in. square and 100 ft. long, weighs about 20 tons.

In designing such a pier it is necessary to drive test piles of wood in advance, so as to determine bottom conditions. Borings are also made. In the plans, the length of each pile is specified. If it turns out to be too long when actually driven to refusal, the top of the pile is blasted off with dynamite, and if it turns out to be too short, it is built up by concrete to the proper level.

The top of the pile, during the driving, is protected by a rope cushion, and a wooden block about 6 in. thick, and usually the point is not protected at all. In sea-wall construction, however, where a loose rock fill is first put in at the base and then piles are driven through the rock as supports for the deck or bulkhead wharf, a hole is made for the pile by driving a wooden "bull-dozer" ahead of it, and the point of the pile is often protected by a steel shoe.

Thus far piles have been driven only into good, firm holding-ground, securing usually a penetration of about 30 to 40 ft. Much of the water-front is very soft mud, running frequently to a depth of 100 ft. or more, before stiffness is found, and in such regions the concrete pile has not yet been used.

Results already obtained in handling piles up to 106 ft. long and 20 in. square are encouraging the commission to try even larger piles in some contemplated work, and very likely before long piles 115 and 125 ft. long and 2 ft. square may be tried. Of course, such piles will necessitate specially built drivers.

The cylinder form of concrete supports may be divided into two main types as used in the harbor of San Francisco. The first type was introduced about 15 years ago and has been entirely abandoned because of its deficiencies manifested by the lapse of time in many piers.

The composition of this type was as follows: Wooden piles, sometimes one, sometimes three close together, were driven to refusal, the tops coming up to near the wharf deck, then a wooden stave form of cylindrical shape was placed around them and driven into the bottom, no steel reinforcement being used, and then the concrete was poured in and allowed to set as best it might. Generally speaking, the mud was too deep to permit one to say that there was any bed-rock or hard bottom at all under this construction. Such cylinders were about 3 ft. in diameter.

The design of such cylinders, which almost uniformly proved failures, contemplated that the bottom of the concrete would extend about 2 ft. below the mud line. The calculation was that this was sufficiently deep to guard against shifting or other removal of the mud, that might in consequence expose the wooden piles to the attacks of the voracious teredo. This calculation proved futile. Modern vessels with their swift and powerful propellers raised such a disturbance of the waters, that the mud was whipped or sucked away from the supporting wooden piles; the teredos thereupon honeycombed them in short order, and the concrete columns above them necessarily fell into the water. This was a common occurrence in piers so designed.

Such cylinders were all built without steel reinforcement, but the absence of the reinforcement was manifestly not the particular cause of failure in this instance, as the whole cylinder fell when the wooden supports were eaten off by the teredo.

Another serious mistake, with costly consequences, was made by pouring the wet concrete mixture into the cylinders without removing the water from the bottom of the form. The result invariably was that such wet mixture deposited in water never did set into true concrete at all, since the cement was practically washed out of it. Disintegration of the bottoms of such cylinders followed rapidly.

Profiting by the experience of their predecessors, the engineers in the past four years have improved on the old type of concrete cylinder and in the actual work of installing them in several noticeable respects. This type is really founded on an entirely different principle.

If wooden piles are used to support the cylinder, as they must be in mud bottoms where there is no bed-rock, the piles are driven to about 8 ft. below the permanent dredge line and come up into the concrete cylinder only about 5 ft., the theory being that the wood supports the cylinder and then the cylinder supports the wharf. This arrangement, it is believed, guards sufficiently against the possibility that the wood will by shifting of the mud become exposed to teredo attacks.

The method is first to drive a steel shell, or caisson, in cylindrical shape into the bottom, so that it can be sealed. The mud is dredged out of it and the water pumped out, and the wooden form with the steel reinforcement already set in it is lowered into the steel shell. Great care is taken to clean and dry the bottom of the form as thoroughly as possible, and then the concrete mixture is poured in and tamped down by hand. After the concrete is set, the steel shell is pulled off by the pile-driving apparatus and again used elsewhere. Steel reinforcing rods are always used, usually ¾ in. square, and from 8 to 12 rods in each cylinder. The concrete columns when finished are from 3 to 4 ft. in diameter. Spiral wire hooping is also used around the reinforcement, as already described with respect to the concrete piles.

The mixing of the concrete is carefully inspected by competent inspectors; the cement, steel and concrete are tested by the testing engineer; and the cement is bought by the Commission and furnished to the contractor for the work. The concrete mixture now used in the harbor of San Francisco, the proportion of cement to the aggregate is 1 to 5 in the pile, and 1 to 6 in the wharf deck and cylinders.

The experience with cylinders has warranted the deduction that where at all practicable the cylinders should rest on any bottom hard enough to carry the load, thus avoiding the use of wooden supports below them.

In San Francisco harbor, as far as it has been improved, such bed-rock has been found in only one limited district, and in that stretch seven piers have been built, supported by concrete columns or cylinders of the type last described, and going down to hardpan and without any wooden supports under them at all. These piers range from 130 to 200 ft. wide and from 650 to 800 ft. long.

CORROSION OF MACHINERY PARTS IN PANAMA CANAL LOCKS.

Corrosion has seriously affected certain parts of the machinery of the locks of the Panama Canal, according to annual report of Gen. Geo. W. Goethals, Governor of the Canal. The report states that observations during the past year disclosed that the corrosive action on the cylindrical valves had been severe. In July, 1915, the west flight of Gatun Locks was drained, and all the accessible cylindrical valves were examined. Marked corrosion was taking place on certain parts of the valves, although the entire valve was made of cast iron or steel, no bronze parts being adopted in the original design. In the lower level an average of 75 per cent of the seal segment nuts were corroded; in some cases fully half the nut had disappeared. It was also found that the bolts holding the stops in place were in such condition that they had to be replaced in every valve in the lower level. All valves were put in good condition and painted with red lead. On the Pacific locks no examination was made of the valves at Pedro Miguel or those on the west side of the Miraflores center wall, but the east valves at this site were found to be in good condition; however, as all painted surfaces of the valleys had failed, it was decided to coat all exposed iron and steel surfaces with enamel, and a contract was entered into for doing this work.

Considerable corrosion has taken place in the rising stem valves. The 1½-in. plates have been attacked in a manner similar to those on the lock gates, and portions in the vicinity of the rivets in the lower valves at Gatun and the upper and lower valves at Miraflores have been violently attacked. The bottom seal casting of the valve which comes in contact with the babbitt metal seal on the bottom of the valve is being rapidly eaten away. A number of the valves at the Pacific locks were in such condition that the bottom seal had to be machined off to make the valve tight. In order to protect the valve from any further electrolytic action between the cast-steel seal and the lower babbitt metal seal, all babbitt metal was removed and replaced with a seal of greenheart lumber. Some of the bronze side seals and springs were found to be broken both at Miraflores and Gatun. Otherwise the seals were in good condition and required only a small amount of draw filing to make the contact surfaces perfect. The top gate valve seal is of cast steel and is held in place by bronze bolts. In practically every instance the corrosion has been excessive around the heads of the bronze bolts, cutting away the metal and in some cases allowing the bolts to loosen and fall out. Several castings had to be replaced. The worst case of corrosion of the seal occurred on the upper valves at Miraflores.

At Gatun practically all valves were installed with fixed side seal castings, which all gave evidence of considerable corrosion, but not sufficient to cause any leaks. At Miraflores removable side seal strips were of machinery steel, and in every case corrosion had reached such a point that all side seals had to be replaced. Inasmuch as the corrosion had apparently been aided by the proximity of the bronze side seals which bear upon them, it was decided to replace all machinery steel with lignum-vitae wood, in this way tending to place an insulating substance in contact with the bronze. All porous concrete around the fixed irons was removed and replaced with cement, and wherever babbitt metal had been used to fill the recessed holes for bolt heads at the Pacific locks the metal was removed and replaced with cement.

At both the Atlantic and Pacific locks considerable corrosion of roller trains has occurred, the rollers of which are made of tool steel. At the Atlantic locks a number of rollers, bolts, and filler castings were missing. All were replaced, and the heads of all bolts were riveted over to prevent further losses. Similar conditions were found at the Pacific locks, and as it is impossible to protect the rollers by any paint, arrangements were made to install ½-in. pipe from the tunnel floors down to the base of the roller-train tracks. Crude oil is forced through the pipes, and it is believed from the results of experiments made with a model that the crude oil will rise along the surface of the roller-train track and in this way protect the rollers by coating them with oil.

As a result of the examination of the valves at Gatun it was decided to have them coated with bitumastic enamel. At the Pacific locks more complete protective measures were taken, as follows: (1) All bronze side seals were lined up and strips of zinc bolted to the valve each side of the seals at the bottom of the valve; (2) where necessary, the bottom valve seal was machined off to give solid metal contact with the bottom seal; (3) all removable side seal strips were taken out and replaced with lignum-vitae wood strips. Where removable strips were not installed, the fixed irons were milled down to take the wooden side seals; (4) all babbitt metal used in the essembly of the valve for imbedding and protecting bolt-heads from corrosion and for calking purposes was removed and replaced with cement; (5) all babbitt metal used in the bottom seal was removed and replaced with greenheart lumber; (6) all steel work of the valve was coated with bitumastic enamel. This left only the bronze side seals exposed; (7) all fixed irons were coated with bitumastic enamel; (8) the channel iron supports for the rollers were coated with bitumastic enamel and arrangements made to lubricate the roller trains and tracks with crude oil during operation and while the valves are submerged; (9) all submerged portions of the valve stems were coated with bitumastic enamel; (10) all bronze bolts are being replaced with steel as fast as breakage occurs.

PRESENT STATUS OF CITY MANAGER PLAN.

The accompanying tabulation from the Short Ballot Bulletin shows the commission-manager cities in this country and the name and salary of the present city managers. The list is corrected to Feb. 1, 1917.

City.	Population.	Date in operation.	City Manager.	Salary.
Sumter, S. C.	8,109	Jan., 1913	E. S. Shuler	......
Hickory, N. C.	3,706	May, 1913	J. W. Ballew	$ 1,500
Morgantown, N. C.	2,712	May, 1913	C. T. Cain	1,200
Dayton, Ohio	116,577	Jan., 1914	H. M. Waite	12,500
Springfield, Ohio	46,921	Jan., 1914	C. E. Ashburner	6,000
Phoenix, Ariz.	11,134	Jan., 1914	R. A. Craig	5,000
La Grande, Ore.	4,843	Jan., 1914	Fred Currey	2,400
Amarillo, Tex.	9,957	Jan., 1914	M. H. Hardin	2,400
Cadillac, Mich.	8,375	Jan., 1914	T. V. Stephens	2,500
Manistee, Mich.	12,381	April, 1914	Charles E. Ruger	2,000
Montrose, Col.	3,252	Jan., 1914	J. E. McDaniel	1,800
Taylor, Tex.	5,314	April, 1914	W. F. Dozier	2,600
Denton, Tex.	4,732	May, 1914	Sam C. Gary	......
Collinsville, Okla.	1,324	Sept., 1914	Claude Thorpe	......
Lakeland, Fla.	3,719	May, 1914		
Big Rapids, Mich.	4,519	1914	Walter Willets	1,200
Jackson, Mich.	31,433	Jan., 1915	Gaylord E. Cummin	6,000
Sherman, Tex.	12,412	April, 1915	O. J. S. Ellingson	......
Bakersfield, Cal.	12,727	April, 1915	Wallace M. Morgan	3,000
Yoakum, Tex.	4,657			
Beaufort, S. C.	2,486	April, 1915	H. G. Otis	......
Tyler, Tex.	10,400	April, 1915	Clay Hight	......
Newburgh, N. Y.	27,805	Jan., 1916	Henry Wilson	4,000
Sandusky, Ohio	19,989	Jan., 1916	K. B. Ward	3,600
Ashtabula, Ohio	18,266	Jan. 1, 1916	J. Warren Prine	2,500
Niagara Falls, N. Y.	30,445	Jan., 1916	Ossian A. Carr	5,000
Wheeling, W. Va.	41,641	July, 1917		
Alpena, Mich.	12,706	April, 1916	Harrison G. Roby	2,500
Santa Barbara, Cal.	11,659	Jan. 1, 1916		
San Angelo, Tex.	10,321	April, 1916	E. R. Wells	......
St. Augustine, Fla.	5,494	April, 1915	W. L. Miller	3,600
Westerville, Ohio	1,903	Jan. 1, 1916	Ray S. Blinn	1,500
Elizabeth City, N. C.	8,412	1915	J. C. Commander	......
Webster City, Ia.	5,208	Jan. 1, 1916	H. G. Vollmer	1,800
San Jose, Cal.	28,946	July 1, 1916	Thomas H. Reed	6,000
Watertown, N. Y.	26,730	Jan. 1, 1918		
Portsmouth, Va.	33,190	Jan., 1916		
Albion, Mich.	5,833	Jan. 1, 1916	Roland Remley	3,000
Brownsville, Tex.	10,517	Jan. 1, 1916	Frank R. Williams	3,000
Petoskey, Mich.	4,778		Vacancy.	
East Cleveland, Ohio	9,179	Jan., 1918		
Grand Rapids, Mich.	112,571	July 1, 1917		
Alameda, Cal.	23,383	March, 1917		
Hot Springs, Ark.	14,434	May, 1917		

In addition there are officers called managers in the following towns, which do not have commission-manager charters or lack some of the fundamental features of the plan: Staunton and Fredericksburg, Va.; Norwood, Mass.; Inglewood and San Diego, Cal.; Glencoe and River Forest, Ill.; Grove City and Titusville, Pa.; Morris, Minn.; Clarinda and Iowa Falls, Iowa; Clark, S. D.; Tucson, Ariz., and Roswell, N. Mex.; Terrell, Tex.; Grand Haven, Mich.; Alhambra, Cal. In Canada: Port Arthur, Ontario, and Maissonneuve, P. Q.

There are state-wide laws permitting cities to adopt this plan in Massachusetts, New York, Virginia, Ohio, Iowa and Kansas.

RECENT TENDENCIES IN INDUSTRIAL BUILDING CONSTRUCTION.

An investigation was conducted last year by Mr. W. P. Anderson, president Ferro Concrete Construction Co., Cincinnati, O., to determine the types of industrial buildings erected during the period 1905-1915 and part of 1916 in the middle states. The results of this investigation were presented by Mr. Anderson at the recent meeting of the American Concrete Institute. Reports were asked of a selected list of manufacturers in various fields, the principal industries covered by the inquiry being those represented by manufacturers of all classes of metal goods, breweries, manufacturers of textiles, paper, leather, boots and shoes. Over 1,300 replies were received. Many of these indicated that no building had been undertaken within the years specified, or gave no information, while others included several buildings. The data utilized by Mr. Anderson were contributed by 320 concerns and cover 1,230 buildings, all used for industrial purposes.

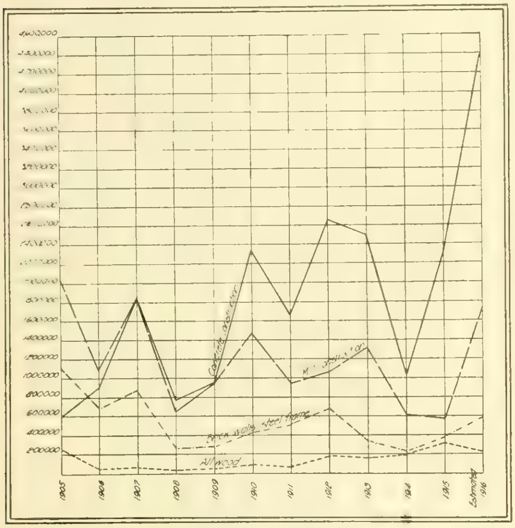


Fig. 1—Total Floor Area of Four Principal Types of Construction of New Buildings.

Mr. Anderson segregated the structures into four groups, all wood, mill construction, concrete construction and brick walls, steel frame, and gave the following figures for these types for the years in question as follows:

TABLE I—FLOOR AREAS OF FOUR PRINCIPAL TYPES OF CONSTRUCTION IN THE CASE OF NEW BUILDINGS REPORTED FOR EACH YEAR, 1905-1916.

Year.	All wood.	Mill construction.	Concrete construction.	Brick walls, steel frame.
1905	262,137	2,470,425	617,739	1,117,723
1906	59,700	1,092,566	901,940	700,326
1907	65,572	1,840,754	1,868,769	895,189
1908	31,954	658,232	789,741	271,532
1909	52,808	952,241	974,390	282,427
1910	95,532	1,468,990	2,358,067	434,495
1911	63,691	958,250	1,660,243	513,363
1912	182.308	1,061,828	2,658,554	684,547
1913	166,091	1,329,329	2,500,121	341,013
1914	200,235	612,338	1,010,153	214,984
1915	323,667	572,949	2,375,039	491,958
1916	225,081	1,705,785	4,363,975	585,521
Total	1,728,376	14,723,687	22,078,731	6,533,078

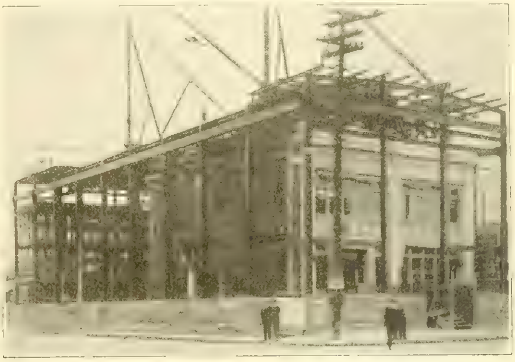
Mr. Anderson states that the first three divisions are reasonably definite in their limits, but the fourth—covering as it doubtless does many one-story buildings—leaves one in doubt regarding the material of the floor and the roof.

On the same basis of segregation the returns year by year are graphically presented in Fig. 1 for the four major classifications. Of course the abnormal disturbances during 1914-16 account for the great fluctuations in that period.

METHOD OF ERECTING A NEW BUILDING AROUND THE OLD STRUCTURE.

In enlarging the building occupied by the Highland Park State Bank, of Detroit, Mich., the method illustrated is being employed to prevent the necessity of moving into temporary quarters during the alterations.

Completely surrounding the present bank, a steel skeleton is being erected that will triple the capacity of the building. The old offices are gradually torn down and moved out, as the work progresses, the offices moving into the rear of the new structure as the razing is being done. The bank will be of steel construction with an exterior of stone, finished inside with marble and will be 50x150 ft. in dimension.



Erecting a New Building Around an Old Structure.

CAUSES AND EFFECT OF VIBRATION IN TEXTILE-MILL BUILDINGS.

An outline of the principal causes and effects of vibration occurring in buildings occupied by textile manufacturing processes was given by Mr. G. H. Perkins, head of the Textile Engineering Department of the Lowell (Mass.) Textile School, in a paper presented at the last annual meeting of the American Society of Mechanical Engineers. The paper is printed in the February Journal of the Society, from which the following is abstracted:

Nature of Vibration in Mill Floors.—In the textile mill, vibration most commonly results from the unbalanced resultant of forces set up by certain classes of machines, synchronizing to some extent with the natural period of the structure, or of one of its elements, usually the floor. From any evidence available it would appear that the actual movements do not not agree, except for exceedingly brief periods, with the "free" natural vibration of the floor and are therefore of a "forced" character. This is doubtless a fortunate circumstance, so far as integrity of the structure is concerned, and cases are rare where vibration has been the direct cause of a building failure. The historic Pemberton Mill disaster occurred in a building noted for its freedom from vibration.

Two distinct classes of movements are commonly found in textile-mill floors: (a) Horizontal movements of floor, more or less independent of walls, of comparatively low frequency and large amplitude. These may properly be classed as oscillations. (b) Movements of higher frequency and less amplitude, often in a vertical plane, which may be considered as no more than tremors.

While vibrations may exist in all three planes simultaneously, they are under textile-mill conditions more apt to be strongly emphasized in only one direction. These motions may properly be considered as truly harmonic in character, and their period. frequency and amplitude defined as from a sine curve.

Causes of Vibration in Textile Mills.—The principal factors contributing to vibration in textile-mill buildings are:

1. Unbalanced machines. 2. Inherent weaknesses in the structure, such as thin walls, light floors with long spans, and unsuitable connections between floors and walls. 3. Poor soil conditions contributing to relative freedom of foundations and footings. 4. Sympathetic vibrations originating outside the building. These are frequently set up by water falling over dams, reciprocating engines in adjacent buildings, or by railroad trains. Their mode of transmission is often obscure, although it is sometimes direct, as through pipe lines or solid ledge.

Effects of Vibration.—Objectionable effects of vibration in textile mills have been noted by various observers as follows:

(a) Settling of foundations and footings on poor soils, with resultant cracking of walls and unleveling of floors, due to a "shaking-down" process of buildings subject to excessive vibration. (b) Effect on operatives. This is usually manifested by apprehension of the failure of the building, loss of efficiency due to fatigue, and the serious effect of continued vibration on the nervous system. (c) Effect on production of textile machinery.

Many consider that the matter of increased power consumption of shafting due to vibrating floors is important, but no authentic tests covering this point are available.

Elimination of Vibration.—The elimination of vibration of an existing building of mill construction is usually attempted by:

(a) Stiffening and strengthening of floors by additional columns or trusses and making more secure connections to walls; also by stiffening outside walls with additional pilasters, or in the case of wooden-frame buildings even by braces or guys.

(b) Balancing of all machines possible and cushioning or absorption of the shocks of machines in which an unbalanced component seems unavoidable. More attention could advantageously be given to the matter of balance in certain classes of textile machines by their builders. Incidentally, the attendant reduction of noise would be beneficial.

The well-known advantages of reinforced-concrete buildings with particular reference to rigidity will not be discussed here, has such construction undoubtedly would obviate a large portion of the difficulties outlined above. There are certain conditions, however, where too great rigidity has been found to be most undesirable for certain classes of textile machinery as at present constructed. Such a large proportion of our textile plants occupy buildings of "slow-burning" mill construction that it is the present purpose to show existing conditions rather than emphasize the advantages of any one type of construction.

Effect of Rigid Floors on Textile Machinery.—The data available covering the comparative operation of textile machinery under similar conditions on rigid and flexible floors are extremely limited, but experience seems to emphasize the following:

(a) In weaving heavy fabrics, the breakage of loom parts has been excessive when looms are mounted on concrete floors with no provision for absorbing the shocks produced. Cushioning the loom feet with absorbents such as wood, cork or rubber, has been found absolutely necessary under these conditions.

(b) Transmission of the noise of machinery to offices, laboratories, etc., has been found exceedingly annoying in some concrete buildings.

Need for Further Study.—The problem of mill vibration, while not new, has yet to receive either full recognition or sufficient serious attention. The resulting economic losses are unquestionably large, if analyzed from all standpoints, and the elimination of vibrations is consequently an important factor in the efficiency of the plant.

All information at present available would seem to point to a general agreement as to the desirability of avoiding excessive vibration in manufacturing buildings. There is evidence of a growing interest in the subject, but the scarcity of authentic results from experimental work along this line, carried on under actual manufacturing conditions, makes exhaustive tests and observations necessary before any general conclusions can be reached.

COSTS OF VARIOUS METHODS OF FINISHING CONCRETE SURFACES.

Cost figures on various methods of surface finish for concrete were given by the Committee on Masonry of the American Railway Engineering Association in its report submitted last week at the annual convention of the association. The report is printed in the February Bulletin of the Association, from which the following notes are taken:

The color of untreated surfaces and of rubbed surfaces is due almost entirely to the cement used. With the other methods of treatment the color and appearance depend largely upon the aggregates and by proper selection and combination of these a variety of effects may be obtained. The coarser the aggregate, the coarser will be the texture of the finished surface. The smaller and more uniform the aggregate, the more closely will the surface resemble natural stone. A mixture of crushed stone and gravel, because of the contrast between the angular surfaces of the stone and the round smoother surfaces of the gravel, gives a more varied effect than either alone. Pleasing effects can be produced by using marble chips or other colored aggregate.

It is the general experience that all treated surfaces darken in time and in many cases begin to lose their neat appearance as soon as finished. A fruitful cause of unsightly discolorations is water seeping through the seam between two layers of concrete not deposited consecutively, causing unsightly discolorations, and many otherwise fine appearing surfaces have been marred on this account.

The use of special finishes is comparatively new among railroads and their wearing qualities therefore have not yet been fully determined. Rubbed finishes of the various kinds seem to have been most commonly used, and a number of roads report neat appearing surfaces in good condition after 3 to 8 and in one instance 15 years. These are about equally divided between cement bricks, carborundum bricks and wooden floats. One road of large experience obtains the best results by rubbing first with wooden floats and then with carborundum bricks, surfaces thus treated being very satisfactory in condition and appearance after 6 years.

Tooled surfaces are reported as showing absolutely no signs of deterioration after 6 years. Other roads report the same condition after 4 years' service.

The following information in regard to costs has been received:

	Ct. per sq. ft.
Grand Trunk:	
Bush-hammering, 250 sq. ft., 1:2½:5 gravel concrete, wages $4 per day	7.2
Rubbing, city arch, 3,900 sq. yd., wages 26½ ct. per hour	5
Kanawha & Michigan:	
Rubbing with cement brick	4
Rubbing until all form marks removed	6
Long Island:	
Rubbed surfaces	1½ to 2
Tooled surfaces	2½ to 3
Michigan Central:	
Rubbing with carborundum bricks:	
1,610 sq. ft. abutment surface	1.6
1,005 sq. ft. pier surface	2.6
4,200 sq. ft. abutment surface	2.8
4,600 sq. ft. pier surface	1.1
Average	1.9
New York Central:	
Rubbing with wooden floats and carborundum bricks.	
Varied from	2¼ to 6⅓
Average	1⅔ to 5½
New York, Chicago & St. Louis:	
Bush-hammering, 1,960 sq. ft.	11.75
Bush-hammering, 5,000 sq. ft.	9.61
Bush-hammering, 8,280 sq. ft.	10.84
Bush-hammering, 3,420 sq. ft.	6.21
Rubbing wood floats, 6,250 sq. ft.	0.57
Paneled posts, complete, per sq. yd.	$19.19
Philadelphia & Reading:	
Bush-hammering	7
Seaboard Air Line:	
Scrubbing	5.50

The Pennsylvania Lines west of Pittsburgh, Northwest System, treated several small areas of surface for the purpose of observing the effect and give the following results:

(1) Tooth-Axed: Area 18.5 sq. ft. "Made a fairly good finish."

(2) Six-Point, Bush-Hammered: Area 16 sq. ft. "A very nice finish, but a little too fine."

(3) Four-Point, Bush-Hammered: Area 15.4 sq. ft. "A very good finish, perhaps the best."

(4) Beam-Hammered: Area 15.4 sq. ft. "Very much the same as No. 1."

(5) Crandled: 10-lb. hammer, area 16.2 sq. ft. "Very much the same appearance at Nos. 1 and 4."

All were done by the stonecutter by hand at a cost of 22 to 26 cents per square foot.

The conclusions were as follows:

1. For all work not requiring decorative treatment, spaded finish is recommended as the most durable, the most readily applied and the most economical.
2. Coating with a wash of cement is not recommended.
3. Rubbing with carborundum bricks or wood floats is next to spading in ease of application and cost.
4. Tooling, alone or with rubbed margins and outlines, produces the most pleasing appearance, and where ornamentation is desired, these and the scrubbing methods are recommended.
5. Careful form work and continuous placing of the concrete are recommended as essential for all methods.

SLAG AS AN AGGREGATE FOR CONCRETE.

Investigations and tests made to determine the availability of slag as an aggregate for concrete were described by Mr. Sanford E. Thompson, Consulting Engineer, Boston, Mass., in a paper presented at the 13th annual convention of the American Concrete Institute. The investigation by Mr. Thompson covered the following:

The use of slag for plain and for reinforced concrete.

The relative value of slag versus gravel for building construction.

The relative characteristics of slag made from different processes.

The relative value of the same slag under different conditions of age, size and porosity.

The strength of slag concrete with the permissible proportions and stresses to adopt.

The durability of slag concrete.

To properly treat these various questions, several series of tests were undertaken. The data derived from these tests and from a study of previous investigations are summarized in the paper as follows:

The strength of concrete made with slag, such as is obtainable commercially in eastern and northern Ohio, was on the average about 50 per cent higher at the age of 28 days than gravel concrete made with first-class materials.

Using the same proportions by volume as for gravel concrete, about 15 per cent more cement on the average was required per cubic yard for slag concrete than for gravel concrete of the same proportions.

No authentic cases of deterioration of slag concrete made with Portland cement or of rusting of steel imbedded in such concrete have been discovered.

Porous slag produced a concrete of substantially the same strength at 28 days as dense slag. At later ages, the dense slag is probably stronger.

Slag made by different processes and under different conditions showed no marked difference in strength and other characteristics.

An extremely hard, dense, acid slag did not produce a concrete of greater strength than porous, basic slag on a 28-day test.

The weight of the slag concrete tested averaged about 6 per cent lighter than an average gravel concrete. On the other hand, very dense acid slag concrete was heavier than gravel concrete.

Granulated slag sand produced a mortar of inferior tensile strength on short-time tests.

Crushed slag screenings produced a mortar appreciably higher in strength than standard sand mortar.

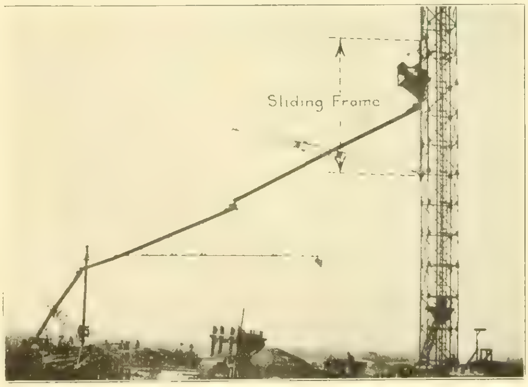
No tests of watertightness of slag concrete were made in this series nor of protection of metal. Tests by other authorities and examinations of structures of slag concrete and tests made with concrete of other aggregates show that when properly laid the steel is protected from rust even although the aggregate is porous.

Tests thus far made of permeability of slag concrete are insufficient to determine its availability for thin, watertight work such as tanks.

The weathering qualities of slag concrete are indicated as satisfactory by examination of structures which have been built for a number of years, but further experimental investigations along these lines with different types of slag are needed before the conclusions as to its use can be considered final.

GRAVITY CONCRETE CONVEYING SYSTEM WITH ADJUSTABLE FRAME AND COUNTERWEIGHTED CHUTES.

A gravity concrete conveyor, designed to facilitate rapid adjustment, is now being used on many large construction jobs. The illustration shows one of these spouting systems as employed in the construction of a reinforced concrete warehouse for the Harbor Commission of Los Angeles, Cal. The spouting system is attached to a sliding frame fastened to a tower. This frame can be raised and reset very quickly, thus doing away with delay in elevating the system for successive heights on the work. The chutes are handled by a boom, and the range of operations can be further increased by a counterweighted section. In the work at Los Angeles Harbor the steel towers were 160 ft. high, and a 50-ft. boom supported a 100-ft. section of spout. The counterweighted section was 50 ft. in length. This gravity system is manufactured by the Insley Manufacturing Co., Indianapolis, Ind.



Insley System as Used in Warehouse of Los Angeles Harbor Commission.

Increased Cost of Buildings at Washington, D. C.—The cost of constructing school buildings and other District buildings in the District of Columbia has increased about 60 per cent since 1898. These structures heretofore have been contracted for at a cost of between 14 and 17 ct. per cubic foot. In the report of the Engineering Department of the District for the fiscal year ended June 30, 1916, it is stated that on account of the great advance in wages and in the price of building materials the buildings to be constructed during the fiscal year ending June 30, 1917, probably will cost from 18 to 20 ct. per cubic foot.

COST OF WOOD BLOCK PAVING ON GOVERNMENT PIER.

Under a contract dated June 26, 1916, with the Franklin Contracting Co., New York City, 978 sq. yds. of wood-block paving were laid on Pier D extension, navy yard, New York, at a cost of $2,376.54. The blocks were short-leaf yellow pine, creosoted, 4 by 4 by 8 in., and were laid on a sand cushion.

The work of placing the 6-in. concrete subbase was done by yard labor. The following unit cost data relative to the construction of the concrete subbase are taken from the April issue of Public Works of the Navy.

The final-cost summary shows that the cost of placing the concrete subbase was $2,645.49, of which $185 was for work not included in the construction of the base itself but incidental thereto. The total money expended in the construction of the base was $2,460.49, divided as follows: Labor, $1,293.65; indirect, $158.28; and material, $1,008.56.

Owing to the fitting out of the U. S. S. Arizona on one side of the pier and the U. S. S. Maumee on the other side, the work was badly handicapped, it being necessary to stop work at times due to blocking of the approaches and the pier. It is estimated that $300 could have been saved had the ships not interfed with the work.

Unit costs of this work are as follows:

Concrete, per cubic qard: Labor, $1.913; indirect, $0.234; material, $3.05; total, $5.197. This does not include the cost of finishing the granolithic surfaces of the railroad tracks. This finish cost: Labor, $119.80; indirect, $29.25; material, $0.00; total, $149.05, or $0.468 per square yard. The cost of material is included in the cost of concrete materials.

Tar-poured expansion joints: Labor, $17.92; indirect, $1.85; materials, $123.49; total, $143.26, or $0.081 per linear foot. The material cost $0.07 per foot.

Attention is invited to the fact that the premolded jointing used on paving on Second and Third Sts. costs $0.046 per foot for material and that the cost of installation is negligible, as the concrete gang places this strip without interference with their regular duties.

The final cost per cubic yard of concrete in place was $10.76, including all expenses and the indirect charges. The final cost per square yard of subbase was $1.803, although the actual cost of labor, indirect, and material of the base was $0.871 per square yard. It will be noted that the incidental expenses of excavating, expansion joints, catch basins, etc., was $0.932 per square yard of paving, or more than the actual cost of the labor and material of the base itself.

NEW ENGINEERING SOCIETY ORGANIZED.

At a convention held in El Paso, Tex., on March 8th, 9th and 10th, the Southwestern Society of Engineers was organized with more than 100 charter members. Membership is open to civil, mechanical, mining, electrical, or chemical engineers, or architects or other persons belonging to a technical profession, who are not less than 27 years of age, and who have been in active practice of their profession for at least six years. Provision is also made for associated, honorary and affiliated members.

It is planned to hold at least two conventions of the society each year for the reading and discussion of professional papers and for social intercourse.

At the first convention the following papers were read and discussed:

"The Purpose of Engineering Education," by Dean G. M. Butler, College of Mines and Engineering, University of Arizona.

"Some Lessons Taught the Mining Industry of the Southwest by Present Activities and Prices," by Gerald Sherman, mine superintendent of the Copper Queen Consolidated Mining Company, Bisbee, Ariz.

"Modern Highways and the Dividends They Pay," by J. L. Campbell, chief engineer of the E., P. & S. W. R. R.

"Engineering and National Defense," by Lieut. Col. M. L. Walker, Corps of Engineers, U. S. Army, chief engineer of the recent punitive expedition into Mexico.

The officers of the society are: President, Dean A. F. Barnes, School of Engineering, New Mexico College of Agriculture and Mechanic Arts; Vice President (for two-year term), Dean G. M. Butler, College of Mines and Engineering, University of Arizona; Vice President (for one-year term), Dean S. H. Worrell, Texas College of Mines; Secretary, Forest E. Baker, El Paso, Tex.; Treasurer, R. W. Goddard, professor Electrical Engineering, New Mexico College of Agricultural and Mechanic Arts; Director (for three-year term), S. O. Andres, Albuquerque, N. M.; Director (for two-year term), J. N. Gladding, City Engineer, El Paso, Tex.; Director (for two-year term), D. B. Gillies, general manager Carrigan-McKinney & Company, Chihuahua; Director (for one-year term), J. C. Ryan, County Engineer, Cochise County, Arizona; Director (for one-year term), W. E. Robertson, El Paso, Tex.

PERSONALS.

J. M. Weir, heretofore division engineer of the Kansas City Southern Ry., has been appointed chief engineer with headquarters in Kansas City, Mo.

M. P. Northam, heretofore office engineer of the Southern Ry., with headquarters at Washington, D. C., has been appointed supervising engineer.

Christopher Harrison, for the past twenty years city engineer of Everett, Mass., has resigned that position and on April 1 will become city engineer of Montclair, N. J.

John A. de Windt, Jr., a consulting traffic engineer of 40 Wall street, New York City, has been appointed chief of the transit bureau of the Public Service Commission for the First District, New York City.

F. E. House has been elected president of the Duluth, Minn., section of the American Association of Civil Engineers. The other officials include W. B. Palton vice-president and Walter Zimmerman secretary.

John C. Hiteshaw, formerly city engineer of Carlisle, Pa., has been appointed borough engineer and commissioner of streets of Waynesboro, Pa., succeeding George C. Brehmn, who resigned to take up similar work in Massachusetts.

Everett L. Jones has been appointed general superintendent and chief engineer of the Pittsburgh-Hanover Coal Co., with offices in the Vandergrift building, Pittsburgh, Pa. For the past six years Mr. Jones has been chief engineer for Booth & Flinn, Ltd., contractors, Pittsburgh.

C. C. Cook, formerly division engineer of the Pittsburgh division of the Baltimore & Ohio R. R. at Pittsburgh, Pa., has been appointed district engineer of maintenance of way of the West Virginia district at Wheeling, W. Va. Mr. Cook entered the service of the Baltimore & Ohio as an axman in the engineering department of the road, and was rapidly advanced to assistant engineer. In this capacity he served on several divisions of the company's lines until he became chief draftsman at Cincinnati. Following upon this promotion he was made assistant engineer in the chief engineer's office at Baltimore and was promoted in November, 1911, to division engineer at Philadelphia. He was transferred to Pittsburgh in May, 1913, where he has since been located.

OBITUARIES.

Ferdinand W. Roebling, secretary and treasurer of John A. Roebling's Sons Co., died March 16.

John Kasson Howe, a prominent resident of Albany, N. Y., died March 4 of angina pectoris after a brief illness. Mr. Howe, while prominent in the social and business life of Albany, was best known to the engineering and contracting world through his association with The Osgood Dredge Co. of Albany, N. Y., and The Osgood Co. of Marion, Ohio. The Osgood Dredge Co. was organized by Mr. Howe in 1883. Mr. Howe was secretary and treasurer of The Osgood Dredge Co. until its consolidation with The Osgood Co., Marion, Ohio, when he became a director in the latter company and its eastern sales representative. Mr. Howe was recognized as one of the leading dredge engineers of this country, and due to his long association with the development of such machines had a very wide acquaintance among contractors and government officials. While Mr. Howe was always actively engaged in business, he found time nevertheless to do much religious and charitable work, being an influential member of the First Presbyterian Church and president and a member of the board of trustees of the Albany Orphan Asylum. It was largely through his efforts that the latter institution has been brought to its present high degree of success. Mr. Howe was an active member of a number of the leading clubs of Albany, a charter member of the University Club of New York and a graduate of Yale University in the class of 1871.

INDUSTRIAL NOTES.

The Combustion Engineering Corporation announces that Walter H. Wood, mechanical engineer, has become associated with its staff of combustion experts.

The Pittsburgh-Des Moines Steel Co., which operates steel fabricating plants at Pittsburgh and Des Moines, Iowa, has recently opened an office at 1268 First National Bank building, Chicago, Ill. This office is in charge of Max Whitacre, who was formerly in the Des Moines office of this company.

E. B. Goode, for four years metropolitan district sales manager for the Lehigh Portland Cement Co., has been appointed sales manager of the Hercules Cement Corporation, with offices at 30 East Forty-second street, New York City.

James P. Karr has assumed the management of the American Steel Dredge Co. of Fort Wayne, Ind., succeeding J. D. Rauch, who resigned to accept the office of sales engineer of factory installations with the Wayne Oil & Pump Co., Fort Wayne. Mr. Karr is well known in the dredge trade and was instrumental in the invention of the American steel dredge at its inception in 1905, when the factory was located at Logansport, Ind., and after the removal in 1910 to the present plant in Fort Wayne he acted as president until about three years ago. Under the new management all the present types of dredges and their repairs will be manufactured, and in addition Mr. Karr intends to place upon the market a new dredge possessing many new and substantial improvements, the details of which will be announced shortly.

Road and Street Issue
of
Engineering and Contracting

Halbert P. Gillette, *President and Editor.*
W. H. Fogerty, *General Manager.*

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BETTER SALARIES FOR CITY MANAGERS THAN FOR CITY ENGINEERS, AND WHY.

Last week we published a list of nearly 50 "city managers" and their respective salaries. The highest paid city manager is Mr. H. M. Waite, manager of Dayton, Ohio, at $12,500 a year. Dayton has a population of 117,000. Next comes Messrs. Ashburner, Cummin and Reed, each with a $6,000 salary for managing cities of 30,000 to 47,000. But even the smaller cities are paying 50 to 100 per cent greater salaries for city managers than city engineers ordinarily receive in cities of corresponding size.

In the preface to their book on "Cost of Keeping and Management Engineering," Gillette and Dana say:

> The management engineer is more likely to receive a greater measure of reward for his services than the designing engineer, for the results of his work are more strikingly evident to those who employ him.

The city manager is no exception to this rule, even though municipalities are less apt to pay adequate salaries than are companies and individual employers. A city manager can usually show his employers at least some of the savings that he has effected. A city engineer finds it much more difficult to do so.

A city manager by adopting good accounting and cost keeping systems, is in position to make evident the economic progress that occurs under his regime. Usually it happens that prior to a city management plan of government, no accounting system worthy of the name exists in the city as a whole, even though some sort of system may exist in some of the city departments. So the passing from a non-businesslike to a businesslike city government, as evidenced by the introduction of adequate accounting, is sufficient to win public approval.

City management is a special branch of management engineering that is destined to grow greatly in importance.

In one form or another, almost 100 American cities already operate under the city mangement plan. Within a few years the number will be 1,000, and it would not be surprising were 90 per cent of the cities to adopt this form of government within the next 10 years. These are days in which publicity and concerted action bring about radical changes surprisingly quick.

Engineers who have aptitude for executive work should begin serious and thorough self-training for city and county managerial positions. We suggest, as one of the first steps, a study of higher accounting for those who already are grounded in bookkeeping and cost keeping. Hatfield's "Modern Accounting," for example, is a book that can profitably be read and re-read several times. Its bibliography will indicate other books that should be mastered.

There is much trash and more verbiage in most of the books on scientific management. Nevertheless, every engineer who aspires to secure important managerial positions should secure a small library of such books. In our next Planning and Management Quarterly issue, May 30, a selected list of books on management will be published. The permanent literature on management engineering is already large, yet the first book on the subject—"Cost Keeping and Management Engineering"—is only eight years old. The first periodical to run a series of articles on management engineering was Engineering and Contracting, which, eleven years ago, fired the initial broadside.

OBJECTION TO THE DIKE METHOD OF CURING CONCRETE ROADS.

Several years ago there was developed in California what is known as the "dike method of curing" concrete roads. It consists in making small dikes, a few inches high, of earth along the edges of the pavement, and cross dikes every 15 to 30 ft. Water is held in these dikes to a depth of 2 to 4 in., and the concrete is thus kept wet for 10 to 14 days. Mr. J. S. Bright, Jr., Engineer of the San Bernardino County Highway Commission, San Bernardino, Calif., is authority for the statement that the dike method of curing is not good practice in hot weather, because the top sixteenth of an inch becomes chalky in appearance.

The editor has seen several concrete roads in California during very hot weather, where the dike method was used without ill effect. Is not the "chalky appearance" but a form of laittance? If so, is it not due largely to the method of finishing the concrete surface?

Where laittance has thus accumulated Mr. Bright favors letting traffic grind it off before applying the asphaltic-oil carpet, which consisted of two oil coats of ¼ gal. each.

Instead of the dike method of curing, he prefers to cover the green concrete with 3 in. of earth, which is kept wet for two weeks. Then the traffic is turned on for two weeks, after which all but about an inch of the earth is scraped off with a road grader. The rest of the earth is allowed to remain until blown away.

HOW WORCESTER HAS SOLVED THE STREET CLEANING PROBLEM.

For many years the city of Seattle has been celebrated for its cleanliness and low death rate (8 per 1,000). Seattle has used flushing wagons that hurl powerful streams of water upon the pavements and wash them as clean as a kitchen floor. The flushers work at night. Now Worcester, Mass., has adopted the same method, but with a variation that is worthy of notice. In Worcester trolley cars, instead of wagons, are used.

Each flushing car has a 2,900-gal. tank that is filled from sub-surface hydrants. A centrifugal pump on the car is driven by a 45-H. P. motor and delivers 600 gal. per min. at a pressure of 80 lb. per sq. in. Three nozzles on the car itself and two on swinging arms that reach almost to the curb, flush the widest street clean.

The best results are obtained by sprinkling the street with the car about an hour before flushing, for this softens up the dirt. A 40-ft. street requires about 3,000 gal. per mile for the sprinkling and 10,000 gal. for the subsequent flushing, or a total of 13,000 gal. per mile. A car will sprinkle and flush 9 miles of street (averaging about 30 ft. wide) per night of 8 hours, using 95,000 gal. of water.

The American Car Sprinkler Co., of Worcester, has the contract for this work, and its annual charge for a 30-ft. street is about $550 per mile.

A few push-cart men clean up the gutters in the morning, but the rest of the street is left perfectly clean by the flushing. The cost of catch-basin cleaning has been doubled since flushing was adopted, being now about $4 per basin per annum.

It will be evident that this method is cheaper than hand cleaning with brooms, but what is even more important is the fact that flushing is far more effective than brooming. Moreover, sprinkling during the day time is no longer necessary to keep down the dust.

Mr. A. T. Rhodes is street commissioner of Worcester. That this trolley flushing method is growing in popularity, although it was first used in Worcester in 1915, is proved by the fact that six other cities have adopted it, namely, Manchester, N. H.; Syracuse, N. Y.; Malden, New Bedford, Somerville and Springfield, Mass.

Trolley car flushers for streets having car tracks and motor-truck flushers for other streets would seem to constitute an ideal combination for economic and perfect cleaning of city streets. But as we remarked only a short time ago, good pavements are essential in securing effective cleaning of streets, and this part of the problem has not received the consideration that it merits.

City engineers should give local publicity to facts such as those in this article, with a view to supplementing the great sanitary work accomplished by hydraulic engineers. The latter have almost eliminated typhoid fever. Now let city engineers proceed to reduce respiratory diseases by good pavements kept perfectly clean. It can be done

TWO-THIRDS OF BOSTON IS MACADAMIZED.

Boston, with a population of three-quarters of a million, has nearly 400 miles of macadamized streets out of a grand total of nearly 600 miles. This, we doubt not, will surprise many engineers, for it is frequently taken for granted that macadam is a pavement almost entirely extinct.

About 20 per cent of the 400 miles is bituminous macadam and the rest is waterbound. The macadam yardage totals nearly 7,200,000 sq. yd. out of a grand total of nearly 11,200,000 sq. yd. Hence there are about 18,000 sq. yd. per mile.

In addition to the 400 miles of macadam there are 40 miles of gravel streets. Next to macadam in mileage is granite block, of which there are about 102 miles. The mileages of the remaining classes are, in round numbers, as follows:

Asphalt, 23; bitulithic, 12; wood block, 9; brick, 6; plank on bridges, 2; not graded, 3.

The "city proper" contains only 25 miles of macadam, but even this is more than 25 per cent of the total street mileage in the "city proper."

It seems quite evident that for residence streets, even in these days of automobiles, macadam is destined to remain in extensive use for many years. Probably many cities will follow the example of New Haven, which we cited in our last Road and Street Monthly issue, where old macadam is resurfaced and used as a base for a more durable surfacing. In view of the likelihood of the extensive use of old macadam for such a purpose, the editor has given, in another column, the methods and cost of scarifying and resurfacing macadam. Particular attention is called to the supplementary use of a harrow for completing the work of the "picks" in the rear wheels of the road roller.

NIGHT SHIFT WORK FOR ROAD ROLLERS.

In hauling road materials with motor trucks, it is not unusual to work two shifts. If the haul is over poor roads, such night work is not free from risk. The editor has seen a truck "ditched" and badly injured while hauling on "the owl shift."

Night work with road rollers, however, involves no risk. Two 10-hour or three 8-hour shifts may often be worked to advantage.

Mr. J. S. Bright, Jr., states that where a gasoline roller is used, current may be generated for electric headlights by belting a Ford automobile magneto to the flywheel. A spotlight may be riveted to the roller yoke, and the light will always be directly in the path of the roller.

AUTOMOBILE SNOW PLOWS AND THE DESIGN OF ROADS.

During the last winter, much of the snow that fell in New York City streets was scraped into sewer manholes by means of snow plows mounted on motor trucks. On the "Ridge Road" in California, a 2-ft. fall of snow occurred recently, and an automobile agent bucked off some of the snow with a pleasure car upon which he had mounted a steel plow. By taking a run at the snowdrifts, he was able to cut a swath for a considerable distance at each run.

Without doubt, the time will soon come when all main roads will be cleaned with snow plows as fast as snow falls. It seems equally certain that motor truck plows will be used almost exclusively for this purpose. In view of this fact, will it not be wise to dig wider and deeper ditches than is now customary, using the excavated earth to build a roadbed considerably higher than the surrounding country?

Road engineers who have had no experience in railway construction are not always familiar with the reasons why railways commonly build rather high embankments even in level country. It is usually assumed that this is done to secure good drainage of the roadbed, but this is only part of the reason and often the least important part. A low embankment catches drifting snow and causes snow to pile up on the track. A higher embankment likewise catches snow, but holds it from reaching the track.

Country highways are attaining more and more the character of railways. They both carry fast moving, high-powered vehicles, and they must be kept open to traffic every day of the year. Let the highway engineer give more study to the designs of the railway engineer.

GEN. GOETHALS TO BUILD NEW JERSEY ROADS.

Gen. George W. Goethals of Panama Canal fame has been appointed State Engineer of New Jersey. He will have charge of the building of $15,000,000 worth of State roads, and will be consulting engineer for the proposed Hudson River traffic tunnel. It is stated that Gen. Goethals will receive a salary of $15,000, and possibly an additional $5,000 for work on interstate bridges and tunnels.

We make mention of the compensation, because, if we remember rightly, this is the highest salary ever paid to a State engineer. Yet, as we have repeatedly pointed out, the importance and magnitude of State engineering work frequently justifies the payment of an engineering salary of $25,000 or more. Not the least of General Goethal's services to the public, as well as to the engineering profession, has been his demonstration that an engineer can be a great executive. Following such demonstrations the public is gradually coming to realize that it pays to employ skilled management engineers at high salaries.

A few years ago the late Maj. Cassius E. Gillette was employed at a salary of $15,000 to manage the water department of Philadelphia, but his salary was guaranteed by a few wealthy citizens, because the city itself could not be counted upon to retain any appointed official over night.

Industrial, mining and manufacturing companies often pay engineers salaries that seem fabulous when contrasted with the highest that are attainable in public office. Thus, John Hays Hommond is reputed to have received half a million dollars a year for his services as a mining engineer. The president of the Bethlehem Steel Co., Mr. Grace, an engineering graduate of Lehigh, last year received $1,000,000 in salary and bonus. This, we believe, is the high water mark of salaries earned by engineers. It may be said that in such instances the high compensation is not for engineering, but for executive ability. Yet it may well be asked where the one leaves off and the other begins. Management engineering is a composite of administration and engineering. This is a relatively new field that engineers are entering with such striking success.

EDITORIAL COMMENT.

In accordance with its annual custom Engineering and Contracting presents in this issue its statistical summary of the road and pavement construction for the past year. Our first compilation of pavement statistics was printed in the March 27, 1907, issue. This was the first attempt by any technical paper, so far as we know, to publish data of this kind, based on information collected directly from city officials.

A trucking firm in Southern California was awarded a contract for hauling road materials at prices ranging from 18 ct. per ton for a mile or less, to 96 ct. per ton for 8 miles. Its prices for intermediate distances indicate that the formula used by the firm was: To a fixed price of 7 ct. per ton add 11 ct. for each mile of haul.

As remarked in another column, much snow is removed from New York City streets by scraping it into sewer manholes. Is this not the ideal method of keeping city streets free of snow? Would it not pay every northern city to investigate carefuly the problem of snow removal by means of automobile snow plows and running water?

Who will be the first county manager? San Diego County, California, might have had this distinction had the new charter not been defeated at the recent election. It was provided in the charter (as explained in our Mar. 28 issue) that the county manager was to be ex-officio county engineer and road master. There are 1,700 county engineers in our 2,700 counties. Let every engineer start local agitation for a "county manager plan," similar to the successful "city manager plan," and it will not be long before there will be county managers by the hundreds.

Speaking of the defeat of the new San Diego County charter, Mr. H. S. Gilbertson, Executive Secretary of the National Short Ballot Organization, New York City, says: "It is encouraging to find so much interest in the engineering profession in improved methods of government." It will pay engineers to get in touch with Mr. Gilbertson, for his organization has already been a power in extending the city manager plan. He says: "We want to hear more and more from the engineers and to get their support for every movement which looks in the direction of solid responsible organization of government to secure efficiency and democracy." Write to Mr. Gilbertson now and ask him to indicate what the Short Ballot Organization is doing, and ask what you may personally do to secure more efficient government.

Indiana and Kansas now have State Highway Commissions. In Kansas the Commission is to have supervision over all but township roads; and each board of county commissioners is required to select a county engineer to have charge of county road work. But where were the engineers of Kansas when the bill was framed that fixed the salaries of county engineers? Counties of 10,000 to 15,000 population can pay the county engineer $1,300 a year, and counties of 30,000 or more must pay the munificent sum of $2,000 a year! Wake up, you engineers of Kansas, and get this law made right before its shell has hardened.

Every reader can render a service, greater than he may realize, if he will mention the paper in which he has seen the advertisement, when he writes to a manufacturer for a catalog or information. The service is three-fold: (1) To the advertiser, (2) to the paper, and (3) to the reader. The first two services are obvious, and it takes but little thought to appreciate that in proportion as a periodical thrives financially, it gives a better service to its readers. Note the contrast between English and Continental engineering periodicals and those in America. Americans have learned the educational efficacy of advertising, while Europeans scarcely know, as yet, what can thus be accomplished. Consequently the American technical and trade press leads the world as pronouncedly in its articles and news as it leads in its advertising.

The Oregon legislature has changed the State highway law. A highway commission of three non-salaried men will select a highway engineer whose salary is not to exceed $5,000. The old, inefficient "road supervisor system" is abolished, and a county roadmaster is substituted. The citizens are to vote June 4 on the new law which provides an appropriation of $1,800,000 to be expended in cooperation with the Federal government and $6,000,000 for hard surfacing of county roads that have been graded by the counties.

SPECIALIZATION METHOD OF ENGINEERING AND CONTRACTING.

To the Editor: In reference to the change you recently made in the grouping of articles in your journal into four subdivisions and making a separate issue of each, I will say that I am very much pleased with the idea. For those who expect to confine their endeavors to one particular line it saves them the tedious work of going through a mass of uninteresting data and segregating the articles they desire to file. If one's work is varied and takes him over the entire field, the articles are classified, indexed and ready for binding in separate volumes under their respective heads. In addition I am of the opinion that where the articles on any subject appear but once each month, more time will be given to their preparation and the tenor of the articles thereby improved.

Personally I hope that the present form will be continued.

E. L. Evans,
Globe, Ariz. Gila County Highway Dept.

ORGANIZATION FOR COUNTY ENGINEERS.

To the Editor: In an editorial in your issue of Nov. 29, 1916, you make the suggestion that you believe it would be a good thing for county engineers to be organized. My idea is that the county surveyors or engineers should be in connection with the state engineer's and state highway commission office of their respective states and should work as a branch or part of those offices. This system, I believe, would make the result more efficient than could otherwise be obtained. It would create a standard of work to which a man must come.

W. I. Hoklas,
Steamboat Springs, Colo. County Surveyor.

COST OF MAINTAINING HORSES AT COLUMBUS, O.

The cost of maintaining horses in 1916 by the Division of Garbage and Refuse Collection of the city of Columbus, O., was 83.7 ct. per horse per day. The average number of horses in the service of the Division was 142 per day. Sixteen men and a night watchman were employed in feeding and caring for the horses. The unit daily cost for each horse, according to the annual report of E. W. Stribling, Superintendent of the Division, was as follows:

	1916.	1915.
Hay, per horse	20	21
Grain, per horse	13	[illegible]
Straw in bedding, per horse	[illegible]	[illegible]
Labor	[illegible]	[illegible]
Hay	.2107	[illegible]
Grain	[illegible]	[illegible]
Straw	.0179	.0217
Veterinary service	.0141	.0151
Supplies	.0268	.0246
Shoeing	[illegible]	[illegible]
Total daily cost of each horse	$0.8370	$0.8300

The item Supplies in the above table amounted to $1,393. Of this total $762 was for harness repairs, the remainder being for storm blankets and covers, drugs, grease, brooms, etc., etc. Hay cost about $14 per ton, corn about 75 ct. per bushel, oats about 50 ct. per bushel and straw about $7 per ton.

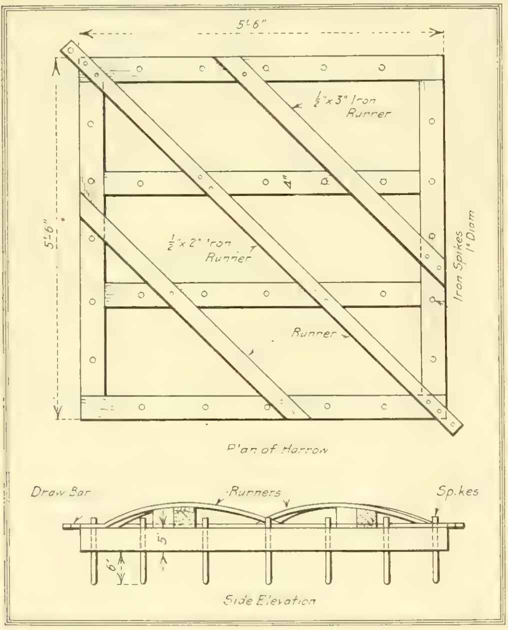
METHODS AND COST OF CHEAPLY SCARIFYING AND RESURFACING MACADAM.

By Halbert P. Gillette.

An immense yardage of old macadam exists in American cities, to say nothing of a vastly greater yardage on country highways. A very large part of this yardage should never be torn out, but should be used as a base for a dustless wearing coat of some kind. Prior to the placing of a wearing coat on the old macadam, it is almost always desirable to scarify and level the surface. Although I first published the following methods a good many years ago, I am constantly seeing much more expensive methods in use.

Using a 12 to 15-ton roller, with picks in its rear wheels, a macadam crust can be cracked to a depth of about 4 in. at the rate of 200 to 240 sq. yd. per hour. On very hard macadam a 10-ton roller is too light for this work and will often not crack half as much as the above given yardage.

The roller simply opens up cracks in the macadam, and a common practice is to follow the roller with a gang of picks to complete the loosening process. If this is done, the cost is about 0.5 ct. per sq. yd. for picking with roller (at $1 per hour) and 1.5 ct. per sq. yd. for hand picking (at 25 ct. per hour). But to this must be added another 1 ct. for re-spreading and leveling the loosened macadam by hand, making a total of 3 ct., exclusive of sprinkling, re-rolling and supervision. The re-spreading and leveling is done with shovels and potato hooks. One man will loosen with a pick (after the roller has spiked up the macadam) and re-spread about 10 sq. yd. per hour.



Harrow for Scarifying.

If the roller is not used to spike up the macadam, a man will not loosen more than about 15 sq. yd. per day (not per hour), and then only to a depth of 2.5 in. instead of 4 in., so it is evident that hand work, unaided by a roller or scarifier, is out of the question.

It is well to soften the macadam crust by thorough soaking with water before starting to pick it. This is particularly true where any hand work is involved.

After macadam has been cracked up by the spikes in the rear wheels of the roller, the best method of finishing the loosening is with a heavy harrow drawn by a team of horses. Such a harrow is shown in the accompanying sketch.

By turning the harrow upside down it rides on the runners shown in the figure, and is thus transported when not in use. The spikes in the harrow not only complete the breaking up of the crust, as well as could be done by hand, but in addition the harrow spikes spread the loosened stone, filling up low places. Remarkably fine loosening and spreading can thus be done at the rate of 100 sq. yd. per hour. Hence, if the team and driver are paid 50 ct. an hour, the cost of harrowing is 0.5 ct. per sq. yd., or one-fifth the cost of doing the same work by hand. We have, then, 0.5 ct. for cracking macadam with roller and 0.5 ct. for completing the loosening and spreading with the harrow, making 1 ct. per sq. yd. exclusive of sprinkling, re-rolling and supervision.

In my Handbook of Cost Data, page 288, I have given the detail cost of scarifying with a "porcupine type" of scarifier pulled by a roller, which was about ¾ ct. per sq. yd., but this did not include any re-spreading of the loosened stone. Evidently, then, there is not much difference in cost between the scarifier method and the harrow method, in so far as loosening the macadam is concerned. The scarifier method has the advantage that it does not wrench or rack the roller as severely as the row of spikes in the rear wheels, and a lighter roller can be used. But I believe that even where a scarifier is used, it will pay well to use a harrow also for leveling and spreading.

If new stone is dumped on the scarified macadam to add to its thickness, use a small two-horse leveler of the "20th Century" type, and finish the top leveling with the harrow, supplemented by potato hooks.

Having loosened and leveled the old macadam for 1 ct. per sq. yd., it remains to re-roll it. This can be done for 0.5 to 0.75 ct. per sq. yd. if the water haul is short. I have had a 12-ton Buffalo Pitts roller consolidate 300 sq. yd. of old limestone macadam per hour, but 200 sq. yd. is a big hour's work unless a great abundance of water is used.

Engineers who have had experience only in building new macadam, and none in re-surfacing old macadam, may be dubious about the solidity of any macadam that is compacted at a rate of 200 to 300 sq. yd. per hour; but they should remember that there is no sub-grade rolling, and that the old macadam is loosened to a depth of only 4 in. Moreover, all macadam has an abundance of fine dust, which hastens the binding, particularly if well flooded with water. Also a heavy roller, run at high speed, is more effective than a light roller at low speed. With a roller at $1 per hour and a sprinkling outfit at 50 ct. per hour, the cost of rolling will be 0.5 to 0.75 ct. per sq. yd. Taking the higher figure, the total cost of loosening, spreading, sprinkling and re-rolling is 1.75 ct. per sq. yd. The cost of the supervision depends on the amount of work in progress, but it should not exceed 0.25 ct., making a total of 2 ct. per sq. yd.

The foregoing costs are based on experience and can be duplicated or bettered by anyone, provided the water haul is short.

Cost of Operating Motor Truck.—The Division of Garbage and Refuse Collection of the city of Columbus, O., uses a Ford truck for the collection of small dead animals. During 1916 the truck traveled 12,920 miles. The expenditure for gasoline, tires, etc., according to the annual report of E. W. Stribling, Superintendent of the Division, was as follows:

Gasoline, 810 gal.*	$173.64
Oil, 26 gal.	10.43
Grease, 32½ lb.	2.42
Patching rubber	.30
Casings, 30x3½	49.02
Casings, 30x3	36.53
Tubes	13.04
Spark plugs	2.76
Miscellaneous parts	1.69
General repairs and parts	35.81
Auto license	5.00
Total	$330.64

*Averaged about 15.85 miles per gallon.

THE CONNECTICUT METHOD OF MAINTAINING CONCRETE ROADS.

The first concrete state highway in Connecticut was placed under construction in the summer of 1913. At the present time 50½ miles have been turned over to the state. This type of highway cost from $1.10 to $1.35 a sq. yd. in 1914, and the last contracts let in 1916 cost the state about $1.80 per sq. yd. Estimates for 1917 are based on an anticipated cost of about $2. The methods employed by the state in the maintenance of these concrete roads were described by Mr. W. Leroy Ulrich, superintendent of repairs, in a paper presented at a recent meeting of the American Concrete Institute. An abstract of Mr. Ulrich's paper follows:

The State of Connecticut builds its mixed concrete roads on a flat subgrade, of a 1:2:4 mixture 6 in. in depth at the edges, and with a cross crown of ¼ in. to a foot. The mixture is reinforced where necessary, and joints are placed transversely about 30 ft. apart. Ordinary tarred paper joints are used, the number of thicknesses of paper depending on the temperature at the time the surface is placed. On roads containing car tracks, joints are placed longitudinally about 2 ft. from and parallel to the rail.

Surface finish is obtained by hand floating and brooming. Concrete roads have also been constructed by the grouting process.

That portion of the Connecticut Highway Department which is responsible for the repairs, maintenance and reconstruction of the highways under its control has been organized to give, as near as possible, the continuous service which is absolutely necessary. It is in charge of one superintendent of repairs, who reports to the commissioner. The State is divided into 10 districts; these being laid out in such a manner that any portion may be easily reached from a central point, at which is established an office with a supervisor of repairs in charge. The supervisor reports directly to the superintendent of repairs. The assistant superintendent is also in charge of one of these districts. Each of these is in turn divided into sections with a foreman in charge of each section, who reports in turn to the supervisor of repairs of the district in which his section lies. These foremen may act alone as a patrolman, or may handle up to 10 or 15 men, depending upon the work necessary in their section, and the season of the year. In order that this system be not too rigid, there are in each district one or more floating gangs which may be transferred from place to place to take care of reconstruction, oiling, or any work which might be neglected, were they not available. This organization handles all the work of the repair department, with the exception of large reconstruction contracts.

Certain features of the construction of concrete roads are, in themselves, causes of wear. The most prominent of these are joints. Any break or unevenness in the surface of a concrete road is an invitation to the traffic to start the process of destruction, and most of the work which has been necessary on the surface of the concrete roads of Connecticut has been the treatment of the joints. The State has not experimented with leaving out the joints or lengthening the distance between them, because in its experience with grouted concrete pavements cracks have developed in them with surprising regularity. A straight well-made joint can be much more easily taken care of than any ragged crack which might result if no joint were used, or if the distance between were lengthened. All joints are treated with tar during the hot weather of the first summer after the completion of the work, and as often thereafter as necessary, but only in warm weather. A tar kettle of about 150 gal. capacity, a pouring pot of the type used for pouring bituminous filler for brick pavements, a wire push broom and a couple of laborers, comprise the outfit necessary to properly take care of this work. The joint is first brushed clean, then filled with tar and covered lightly with sand or stone chips which have previously been distributed along the road. The cost of this work varies with the conditions of the joints and price of labor. Another defect which will sometimes appear is due to foreign material introduced into the mixture during the process of construction, such as bits of wood, pieces of coal, barrel bungs and the like, which crush or work out of the surface and afford a chance for wear. It may be said that this condition should not arise, but these foreign materials are found in the surface once in a while, although no one seems to know how they got there. The small holes thus caused are detected before any serious damage is done and repaired with the same process as the joints.

The use of a poor quality of sand caused some trouble on the earlier roads by not offering sufficient resistance to abrasion, causing a resultant slight wear on the surface. This occurred only on the first two contracts, and was discovered and remedied at once by a light coat of hot tar broomed onto the spots which showed wear. This tar was covered with a dusting of sand. Only a few small spots developed and these have given no further trouble.

The use of too wet a mixture, too much hand floating, or a combination of the two, has caused a slight flaking on the surface of one or two sections. This flaking has apparently not yet affected the ability of the surface to withstand abrasion, and no additional treatment has been used.

These inherent or construction defects can be studied, and are now as far as possible eliminated. Very little trouble has been experienced from these causes on the later contracts. On the other hand, even the most careful study of the process of construction, and treatment of the sub-grade conditions, does not always prevent the occurrence of troubles due to conditions arising from the action of ground or surface water, changes of temperature and similar causes. Longitudinal cracks are the most frequent and annoying results of forces exerted after the work has been completed. These occurred more frequently on the earlier contracts which were not reinforced, and also on those which were so situated that the frost could effect an entrance under the road from the sides, lifting each edge and causing cracks to appear when the surface returned to its normal position. These cracks have been treated in exactly the same manner as the joints. Springs and ground water which had never given any trouble on the original road, broke up one slab on the third contract. This is the only renewal which has been necessary.

Practically all of the work on the surface of these roads is performed in the same manner as outlined for tarring joints, and with the use of the same materials. A medium heavy tar which requires heating is used. Any tar which will conform to the following specifications will be found satisfactory:

Specific gravity at 70° F., 120 to 130.
Free carbon, 10 to 25 per cent.
Distillation: Total to 170°, not over 5 per cent. Total to 315°, not over 30 per cent.
Specific gravity of entire distillation at 60° F., 1.033 to 1.038.
Melting point of residue, 115° to 160°.

The size of the sand or fine stone used with the tar should depend on the size of the defect being treated, and should be clean. If defects are treated as soon as they appear, practically no cover will be used larger than torpedo sand.

By following the principle of "A stitch in time saves nine," the surface of those roads has been maintained cheaply and no general surface application has been necessary on any of the contracts.

Actual costs of the maintenance for the various contracts have been kept for a period of two years, and the results are very satisfactory. Twenty-five miles of road have been used in obtaining the figures given, care being used to include those carrying all classes of traffic from the heaviest to the lightest. The actual cost of all tar work applied to the concrete surface has been $38.63 per mile per year, or about 0.4 per sq. yd. of travel path per year. The cost of shoulder work and drainage has been $28 per mile per year, or 0.3 ct. per sq. yd. per year. The actual maintenance costs for the same period over the entire trunk line system of all classes of surfaces has been $585.18 per mile per year, or 6.25 ct. per sq. yd. of travel path per year.

METHODS AND COST OF SCREENING AND WASHING GRAVEL FOR COUNTRY ROAD CONSTRUCTION.

In country road construction, where commercial gravel is not available, various methods have been adopted for utilizing low-grade gravel. The methods employed in Calhoun County, Michigan, for obtaining gravel of extra good quality by means of screening and washing were described by A. A. McKay, County Engineer, in a paper presented at the recent short course in Highway Engineering at the University of Michigan. The matter that follows is taken from Mr. McKay's paper:

Wagon Screens.—The first attempt to improve pit run gravel was by the use of wagon screens—a frame holding a screen about the size of an ordinary wagon box, elevated above the wagon with the lower edge resting on the far side of it. The pit run material was then thrown over the wagon against the screen, which allowed the sand to run through and the gravel to slide down into the wagon. This method is good where the quantity of gravel wanted is small and the quality of the pit allows its use. First cost is low and no special knowledge is required to handle it. The objections to its use are: Inability to secure men who are willing to work under the conditions imposed, that of throwing the gravel the additional height and scattering it over the screen. Cannot be used in pits containing an excess of clay except in dry weather. Usually have to use screen of too large a mesh and the waste of a large per cent of small pebbles. Ideal conditions permit use of ⅛-in. screens and usual conditions require ¼-in. and ⅜-in. screens. The loss of the fine pebble between ⅛ in. and ⅜ in. gives a gravel that does not pack readily and is the cause of much criticism from the traveling public. The average cost of screening gravel by this method will run close to 50 ct. per yard, as follows: First cost of screening, 30 ct. extra; time of team waiting, 8 ct.; extra team scraping surplus sand away, 10 ct.; total, 48 ct.

Timber Trap.—The second trial involved the use of a timber trap and the delivery of material with teams and slip or wheel scrapers to top of trap, allowing it to fall through a hole onto a large flat screen and then into the waiting wagon. On two operations of this kind, obtaining from 1,500 yd. to 3,000 yd., fairly good results were obtained. The first cost of such a trap will run from $100 to $250, depending on location and size. The cost of running material through a trap large enough to accommodate three wagons side by side—No. 1 wagon receiving screened gravel, No. 2 wagon receiving sand and No. 3 wagon receiving oversize stone—on a job requiring around 3,000 yd. was $1 per yard on the wagon. Two yards of sand and ⅓ yd. of stone was taken out for each yard of gravel. Another installation, on a smaller scale, gave a cost around 70 ct. per yard. Objections to this method are rather high cost of material and large amount of waste of lumber at each move and inability to move quickly. Limited amount of material to be secured at each setting. After the bank has been used around the screen for a radius of from 100 to 125 ft., the added expense of bringing the material to the trap is prohibitive. Wasting of fine gravel through over-size screens. Can only be used in dry weather, and is not advisable for use in pits containing any appreciable amount of clay.

Rotary Screen on Top of Bins.—Another method used was by elevating material to a rotary screen on top of bins; delivery made by teams with slip or wheel scrapers. The elevator and screen are run by a gasoline engine. This is a good method where pit is of suitable material. On one installation of this kind the cost ran to $1.50 per yard and it was necessary to abandon the plan. The greatest difficulty was in getting the material through the screens, which would plug up at the least provocation. In extra dry weather they would work with fairly good success, but one day's rain made it necessary to lay off for the next two days to allow the pit to dry out. The officials had to use ¼-in. to ⅜-in. screens and wasted a large percentage of pebble content, and the gravel obtained was so coarse as to be objectionable to the traveling public. The pit contained a small amount of clay, scarcely visible to the naked eye, but plenty enough to clog the screens. In sandy pits, containing no clay, this method is successful and under favorable conditions the cost per yard would probably be not less than 50 ct.

Screener Loaders.—A screener loader consists of an elevator mounted on a truck operating on a light standard-gauge track. The elevator is so situated that it digs or picks up loose gravel from the bank, elevates and discharges onto a flat screen protected by a stationary flat bar stone screen, and delivers the pebble into a waiting wagon. The over-size stone and sand are deposited onto a short belt conveyor or thrown directly to the ground beyond the wagon which is being loaded. The screen is automatically agitated to help keep the material in motion and gives better screening results. The elevator is operated by a gasoline engine mounted underneath, and lower end is placed into the gravel at the bottom of the face of the pit, where two men feed the loose material into the moving buckets. When all the available material is used up the machine is moved along the track a distance of 3 to 5 ft. and the elevating continued. No teams are required, except one to slip away the surplus and stone, in case machine is not equipped with a belt conveyor. In a pit where 1½ to 2 yd. of sand was screened out to each yard of gravel a wagon holding 1½ yd. was invariably loaded in from 8 to 10 minutes. A crew of two men to feed buckets, one man on face of pit, one man on track and one engineer will put out from 80 to 100 yd. per 10-hour day.

Advantages are: No heavy shoveling required of men—not more than one team required to tend machine—loading is carried on quickly, avoiding waste of time of hauling team—number of men in pit reduced—machine is reasonably light and not hard to transport. Disadvantages: Requires pit length of at least 80 ft. for track. Unsatisfactory in wet weather—and in some pits—liability of using too large size of screen and losing small pebbles—first cost. The average cost per yard on a job of 3,000 yd., where from 1½ to 2 yd. of sand was taken out for each yard of gravel, allowing for 4 laborers at $2.25, 1 engineer at $3, 1 team at $4.50, and one-half of foreman's time at $2, and cost of gasoline, was between 23 ct. and 25 ct. per yard, with no depreciation on machinery allowed.

Screener-washer.—The screener-washer consists of the combination of the hydraulic method of washing or sluicing material containing gravel and then removing the gravel. The first operation consists of throwing a stream of water against the gravel bank from a 4-in. hose with 1¼-in. fire nozzle under pressure. The water-saturated earth-sand-gravel is then collected in 15-in. half-round galvanized iron sluices and conducted by gravity on 6 to 7 per cent grade to an endless elevator screen, which intercepts the gravel and earth-laden water, retains the gravel or pebble content and elevates it to a storage bin. The main advantage of this method is that you can get gravel and get it fast from a bank that would not run more than 25 per cent gravel and that you save every pebble from 3/16 in. up. This method was developed by sheer necessity. A partially completed gravel road had exhausted all the gravel within a radius of 4 miles from 11 different pits, and still needed nearly 4,000 yd. for the top course. The washing plant was installed at one of the abandoned pits, where 4 or 5 ft. of about 60 per cent gravel was overlaid with 7 to 8 ft. of yellow sand. The outfit consisted of one 15-H. P. gasoline engine and 3-in. centrifugal pump, 400 ft. of 6-in. spiral pipe, hose and nozzles. Water was obtained from a small pond at the foot of the hill. The elevator-screen was simple. The bottom of the buckets consisted of wires laid 3/16 in. apart, which retained the gravel and allowed the water and sand to pass through. The elevator was run by a 4-H. P. gasoline engine. From the 25 per cent material it was possible to secure 90 to 120 yd. per day of excellent gravel, a great deal of which was below ¼ in. in size. After being placed on the road it packed quickly, and now, after one year of travel, it has become the best 16-ft. gravel road in the county and one of the best in the State. The main reason given for the quick packing and smooth surface is that the small pebbles down to 3/16 in. were saved and filled the voids. The gravel had a very small clay content; in a few instances when the washer was overloaded the pebbles would be coated with a clay film.

On this one installation the county secured for road purposes 4,144 yd. of 100 per cent gravel at a cost of 21 ct. per yard in bin. Everything but depreciation on machinery was charged to the cost of production and the plant has been moved to another location and is being used again.

To duplicate this plant would take the following:

1 15-H.P. gasoline engine	$ 400.00
600 ft. 6-in. spiral pipe	200.00
100 ft. 4-in. fire hose	200.00
Nozzles, fittings, etc	50.00
1 3-in. centrifugal pump	30.00
200 ft. gal. iron sluices	60.00
Screener elevator	750.00
30-yd. gravel storage bin	150.00
1 6-H.P. gasoline engine	110.00
Miscellaneous small tools, belts, etc	150.00
Total	$2,100.00

At the last end of this work the officials used gravel that lay too low to be secured with the hose and used teams and slips to draw the gravel onto a small trap. It took five teams to secure the usual amount of material that had been obtained previously by the hose.

TRACTOR-TRAILER OUTFITS FOR GARBAGE AND REFUSE COLLECTION.

Tractor-trailer outfits are to be used by the Bureau of Streets of Buffalo, N. Y., in the collection of ashes, garbage and of refuse. Tests conducted during the past two months have demonstrated that this plan would save approximately 25 per cent over the method now in use.

At the present time the Bureau has 2 and 3-horse rear-end dump garbage wagons holding 5 to 7 tons. The ash wagons are of the bottom dump type and have a capacity of 5½ cu. yd. The paper and refuse wagons have a capacity of 16 cu. yd. level and 25 cu. yd. round up. The wagons have lately been equipped with Timkin bearings and will be used with the motorized equipment.

Under the new system 7-yd. trailers will leave the barns with teams of horses and will go to the different districts to which they are assigned. The tractors will be so scheduled that they will get to the various districts with empty trailers and drop them off and then take up the loaded horse-drawn trailers and draw them to the dump destinations. It has been found more economical to use horses during the loading of the trailer on account of the stops every 25 or 30 ft. to empty receptacles.

In the different districts in which the tests were conducted it was found that the time of the work could be cut from 8 hours to 6 hours and could be done in a more efficient and cleanly manner. The haulage time for garbage was reduced by means of trailers from 8 hours to 2 hours. The average haul to the garbage reduction plant was 6½ miles. On paper and refuse collection and disposal the time was reduced 60 per cent; on ashes it was cut 40 per cent.

New Asphalt Repair Wagon.—To meet the demand for an asphalt repair outfit of low cost and available for the use of municipalities where no asphalt plants are located, the Iroquois works of the Barber Asphalt Paving Co. has devised an asphalt repair wagon stated to be capable of supplying material for from 50 to 75 sq. yd. of patching per day. The total weight of the outfit is only two tons. It can be used to remelt old asphalt paving or cakes of new mixture made at a larger plant and stored; for heating sand and stone with asphalt cement to make new mixtures, and as a sand, gravel or stone drier or substitute for a melting kettle. The wagon is supplied with a full outfit of paving tools.

METHOD AND COST OF GRADING AND CONSTRUCTING SIDEWALKS FOR A TRACT IMPROVEMENT.

Contributed by F. E. Glass.

This work consisted of the improvement of the streets in a hilly suburban tract, adjacent to the city of Los Angeles, Cal., by grading and constructing about 7 miles of concrete walks, curbs and gutters. The work was done in November and December, 1916, and as the soil was a heavy, stiff clay, the contractor pushed the work with all possible speed in order to beat the winter rains. The excavation was practically complete and the concrete work half finished when the first rain fell in December. Thereafter some delay was experienced because of wet ground.

Grading.—Some heavy equipment, for the size of the contract, was used to hurry the work. Two elevating graders were employed for ordinary grading, one drawn by a gas tractor and the other by 16 mules (six pushing). A steam shovel was used in the heavier cuts and handled about 3,000 cu. yd. of hardpan. As the cut became deeper and the clay harder, the shovel could not fill with less than three tries, so blasting had to be resorted to. The maximum cut was only 9 ft. Holes were sunk by two men on a churn drill and sprung at grade by a stick of 40 per cent dynamite. The spacing was about equal to the depth of hole and the average load was a half keg of black powder fired by an electric battery and a stick of dynamite. The best shots merely heaved the ground, but occasionally a hole would "blow up," and as the streets were in a residence district it was found necessary to lay old planks over the holes to prevent chunks of clay flying and damaging property.

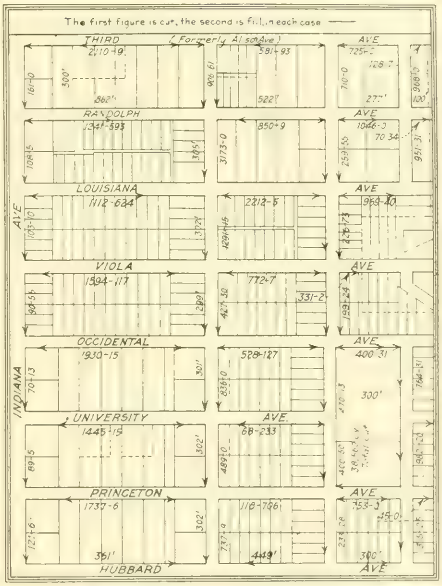


Fig. 1—Map of Road Improvement District No. 124, Showing Earthwork Quantities.

The business-like handling of earth sales is worthy of notice. When the work was awarded, the contractor sent salesmen with blank contracts to the owners of property in the district. They received a commission and sold excess yardage for as much as 40 ct. per cu. yd. for filling lots. Any reasonable terms were considered, with the property as security. This appears to be a far better arrangement than the more common wasting of earth where the contractor does not get the price he wants and spot cash.

All hauling was done in 1½ cu. yd. dump wagons. An item which tended to increase the cost of the earth-work was the inability of the graders to work around power and telephone poles where light cut or fill made their removal unnecessary. This required plowing the cut between the pole line and property line and slipping the earth out into the street, where the grader picked it up.

Because of short notice to the local water company, many pipes and some mains were broken and work had frequently to be discontinued on a street until it could drain and dry out. This water standing in new fills and ditches causes much inconvenience on a grading job and is easily avoided.

Quantities of earthwork are shown on the district map (Fig. 1). The sidewalk and parking was shaped by hand and the earth thrown out to the elevating grader. The street section was then shaped by a road grader drawn by six mules.

All surveys were furnished by the county, but the contractor kept a level man on the job to replace stakes and to check up and direct the graders. As fast as the grading was approved, sufficient sand and gravel for the curb work was dumped in the street. These materials were delivered 6 miles from a Los Angeles gravel plant and several trucks were kept going night and day. This was found cheaper than the alternative 1½-mile haul from a railroad siding, avoiding re-handling and the irregularity of car delivery.

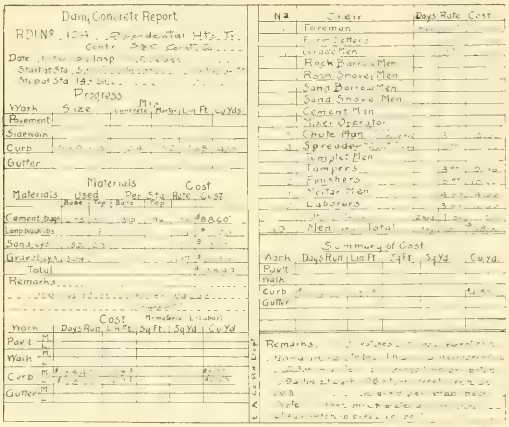

Daily Concrete Report
RDI No.
Date
Insp
Start at Sta
Stop at Sta
Progress
Work
Size
Mix
Concrete
Mortar
Lin Ft
Cu Yds
Pavement
Sidewalk
Curb
Gutter
Materials
Cost
Materials
Used
Per Sta
Rate
Cost
Base
Top
Base
Top
Cement, bags
Lampblack, lbs
Sand, cys
Gravel, cys
Total
Remarks
Cost
M=material L=labor
Work
Days Run
Lin Ft
Sq Ft
Sq Yd
Cu Yd
Pav't
Walk
Curb
Gutter
No.
Crew
Days
Rate
Cost
Foreman
Form Setters
Grade Men
Rock Barrow Men
Rock Shovel Men
Sand Barrow Men
Sand Shovel Men
Cement Man
Mixer Operator
Chute Man
Spreader
Templet Men
Tampers
Finishers
Mortar Men
Laborers
Men
Total
Summary of Cost
Work
Days Run
Lin Ft
Sq Ft
Sq Yd
Cu Yd
Pav't
Walk
Curb
Gutter
Remarks

Fig. 2—Inspector's Concrete Report With Typical Day's Run of Curb Crew.

Concrete Work.—About one-half the cement was furnished by the county, as shown in the cost data below.

The curb, walk and gutter gangs began at the same point and followed in the order named, about a week apart.

The county's resident engineer, in charge of the work, had an inspector with each of the three gangs. Each inspector filled in the day's run of work in feet, size of crew and amount of cement used, on the progress report form shown in Fig. 2, which also gives a typical day's run of the curb outfit, hand-mixing. The resident engineer worked up the balance of the cost, from which the final cost of the job was accurately determined.

The greater portion of the curb work was made by hand mixing. The materials were turned three times dry and three times wet on a 3 ft. x 10 ft. sheet iron strips laid together to form a good mixing platform, readily moved along the street as the work progressed. Ten-bag batches were mixed, which ran about 75 lin. ft. of curb, depending upon the number of openings left for driveways and the amount of low grade (giving overdepth of curb). All concrete on the work was 1:2:4 and mortar was specified 1 part cement and 2 parts sand with 1 lb. of lamp black per barrel of cement used. On the curb finish, the contractor found it necessary to use more cement in the mortar to trowel smoothly.

Carey expansion joints were placed every 40 ft. in curb, walk and gutter and the facing cut through to expose the felt. The curb was 5 in. wide at top, 3 in. at base and 15 in. high, with ½ in. of mortar on top face and ¼ in. of mortar on 4 in. of back and 3 in. of the front face. The gutter line was 8 in. below top of curb on the greater part of the work, the gutter being 5 in. thick and 2 ft. wide, but Ditman street drains the district and here curbs were given 10 in. face and gutters were 5 in. thick by 3 in. wide. All gutters were floated rough and marked every 3 ft. to correspond with the curb marks.

The walk was built 4 in. wide with a 3 in. base of 1:2:4 concrete and a ½-in. top of 1:2 mortar as before described.

TABLE I—ROAD DISTRICT IMPROVEMENT NO. 124, STREETS IN OCCIDENTAL HEIGHTS, LOS ANGELES COUNTY ROAD DEPARTMENT.

Work done—Grading, cement sidewalks, curbs and gutters.
Total length, 4.2 miles.
Average haul, 6 miles.

Actual Cost to Contractor:		
Excavation, 38,563 cu. yd. at $0.279		$10,758.75
Concrete for culvert, furnishing, hauling and placing, 4 cu. yd. at $23.01		92.17
Reinforcing steel for culvert, furnishing, hauling and placing, 330 lb. at 5 ct		19.50
Sidewalk, 3½ in. by 4 ft., furnishing, hauling and placing, 141,050 sq. ft. at $0.07		10,402.64
Detail of Cost of Sidewalk:	Per sq. ft.	
Cement	$0.0244	
Gravel	.0147	
Sand	.0061	
Lamp black	.0009	
Exp. joints	.0004	
Water	.0002	
Grading	.0067	
Moving material	.0012	
Mixing and placing	.0140	
Covering and watering	.0041	
Repairs	.0011	
Total	$0.0740	
Gutter, 5"x2' (17% is 3' wide), furnishing, hauling and placing, 79,383 sq. ft. at $0.080		6,365.28
Detail of Cost of Gutter:	Per sq. ft.	
Cement	$0.0264	
Gravel	.0159	
Sand	.0066	
Exp. joints	.0005	
Water	.0003	
Grading	.0099	
Moving materials	.0020	
Mixing and placing	.0141	
Covering and watering	.0019	
Repairs	.0020	
Total	$0.0800	
Curbs, 5"x9"x15", furnishing, hauling and placing, 35,188 lin. ft. at $0.211		7,416.33
Detail of Cost of Curb:	Per lin. ft.	
Cement	$0.0581	
Gravel	.0350	
Sand	.0145	
Lampblack	.0008	
Exp. joints	.0014	
Water	.0007	
Grading	.0320	
Moving material	.0051	
Mixing and placing	.0474	
Backfilling and watering	.0098	
Repairs	.0058	
Total	$0.2110	
Total cost of work		$35,054.67
Less 2,910 bbl. cement at $1.47 furnished by county		4,277.70
Actual cost to contractor		$30,776.97

The above does not include interest, insurance or overhead expense.

A Chicago paving mixer was used and gave good results. In all the work both sides of the street were carried along together, the concrete being wheeled from the platform or mixer to the forms in barrows.

All cement work was promptly covered with earth which was kept moist for two weeks.

These streets were later oiled and graded by the county. The cost of the improvement is given in Table I. Mr. F. H. Joyner is County Road Commissioner and J. E. Jellick was resident engineer on this improvement.

Cost of Upkeep of Horses at Washington, D. C.—The cost of the upkeep of horses employed in the work of the engineer department of the District of Columbia averaged $156 per horse for the fiscal year ended June 30, 1916. The forage allowance for 1 horse for 1 month was as follows:

100 lb. rye straw, straight No. 2, at 79.6 ct. per 100 lbs	$ 0.80
210 lb. long timothy hay, at $1.04 per 100 lb	2.18
210 lb. mixed clover hay, at $1 per 100 lb	2.10
384 lb. oats, at $1.687 per 100 lb	6.48
50 lb. bran, at $1.27 per 100 lb	.64
Total cost forage for 1 horse 1 month	$ 12.20
Forage for 1 horse for 1 year	146.40
Shoes, 80 ct. per month	9.60
Total	$156.00

PRELIMINARY ESTIMATES FOR HIGHWAY CONSTRUCTION.

The importance of making careful preliminary estimates for proposed road improvements was discussed by Mr. Edward St. C. Smith, Consulting Highway Engineer, Piedmont, W. Va., in a paper presented at the 1917 West Virginia Road School. An abstract of Mr. Smith's paper follows:

Estimates fall short of the actual and final cost from the following general causes: (1) Lack of experience on the part of the engineer in this feature of the work; (2) guessing at quantities; (3) a tendency to use minimum unit costs in an effort to keep the final figures within the maximum amount which the people are willing to expend or that they expect to spend; (4) failure to anticipate possible contingencies affecting the ultimate cost.

It would be far better for all concerned if engineers would adhere rigidly to the rule never to under-estimate, but rather to exceed the cost by about 10 per cent for contingencies that cannot be foreseen. As for the fear of criticism, there will be no trouble in spending the extra 10 per cent before the job is completed if it is desired to "come out even," but it will be a hard matter to pay for the work if the estimate falls short in the end. It always pleases a local board to find that there is going to be a little money left over after the final estimates are paid, but it is not profuse with praise for the engineer if confronted with the alternative of raising more money or being criticised for an unfinished road.

It is well, then, to proceed on the basis of facts and correct figures evolved from cold calculation and the exercise of one's best judgment uninfluenced by too great a desire to please or a fear of disappointing.

The time to have the actual facts as to the cost of a proposed road improvement, is at the outset before the bonds are voted; not after the funds have been exhausted prior to the completion of an underestimated job.

An important feature of correct preliminary estimating is the advantage it affords in determining whether bids are too high and should be rejected. Without such information a board of county commissioners cannot intelligently award a contract or reject bids. It will be found also that the practice of preparing correct cost estimates may affect the unit prices bid. It has been the writer's practice for some years past to submit to prospective bidders detailed estimates of cost of the work advertised, based upon going prices for labor and materials, with 20 per cent added to total as contractor's gross profits. This represented the maximum that we expected to pay for the work and was high enough to allow the contractor a liberal margin for contingencies. In a large number of contracts let under this plan, over 90 per cent have been under the estimates and there has been noticeable a remarkable uniformity in the prices submitted and a lack of unbalanced bids.

The foregoing comment refers generally to unit bids. If what are known as "lump sum" bids are to be received, the importance of accurate estimates is further emphasized. Without dependable information of this kind contractors must protect themselves with ample margins and the final cost of the work is thus increased. In the writer's opinion the lump sum bid system is not economical because the contractor must be paid for "taking a chance" notwithstanding the most careful estimates.

What then can be done that is not ordinarily done to secure accurate and reliable preliminary information on the cost of a proposed work? In the first place, better realization on the part of county officials of the importance of having such information, is necessary. It is not always the engineer's fault that his data are not complete but only approximate, because he is often not given reasonable time and facilities to obtain it. Some people think that all an engineer needs to do is to ride over a proposed road improvement in an automobile and be able then to tell them the exact cost.

A procedure that is often practiced in preliminary estimating and one that has led many an estimator astray, is that of attempting to compute correct quantities from a center line profile. It is often thought that the taking of cross-sections will not warrant the extra time and expense required. Actual results, however, will demonstrate that this is a "penny-wise-pound-foolish" policy. It is not uncommon for the final cross-sectioned quantities, particularly on hillside locations, to show an increase of 100 per cent over the center line profile estimate. There are very few cases in which the little extra time required to take cross-section levels will not be amply justified in the reliable data thus made available. If a projected location is to be made on a preliminary line, topography on each side of the center line is of course absolutely essential.

Another contributing cause of under-estimating is the failure to properly classify materials such as earth, loose rock, solid rock, etc. This is often difficult to do on account of lack of surface indications and here is where good judgment counts most and past experience is the most valuable aid. It is hard to say what is in a hill before it is uncovered, but usually a study of the locality will reveal information which will be of assistance, after which one may be excused for erring on the side of liberality toward the percentage of the difficult material. If embedded ledges of rock are suspected to exist, it will often pay to make test borings to determine their depth, slope, etc.

In some localities, the custom of bidding on unclassified material prevails, in which case the element of chance falls on the contractor and the estimator's work is much simplified, but usually, as in the case of the lump sum bid, the bidder protects himself with a safe margin.

The science of computing the probable cost of any piece of road construction is, at best, not an exact one, and judgment, based on experience on other work and on a consideration of local conditions, must very largely determine the basis on which such an estimate is made.

Some of the items of cost which will be considered by the contractor and which will affect his proposal prices, are:

(1) Taking care of traffic during construction. The season of the year during which the road is to be constructed and the weather conditions at that time, will affect the cost of caring for traffic during construction. If it is necessary to provide a new temporary road around the work, right of way will have to be secured and some compensation may have to be allowed for the latter, in addition to the actual cost of building the temporary road

(2) The cost of unloading and hauling materials. This will be affected by the condition of the roads at time of year the work is to be done and is dependent upon the length of haul, also the kind of equipment used for hauling. It will probably be found economical to keep the roads dragged or otherwise maintained for this purpose.

(3) The cost of under drainage. This is one of the most important items in the cost of any road. Before making the final estimate, the estimator must determine the probable need of under drains and their cost. This requires a knowledge of the character of the material necessary to be moved in placing these drains. Very often a study of the road and of the exposed formation above and below, will disclose valuable information in this connection. It is not always possible to determine beforehand the effect of cutting a hill or changing a grade, upon the flow of sub-surface water, but a careful study of the probable need and location of all under drains is absolutely essential to an intelligent estimate.

(4) The volume of excavation per mile, the free haul limit and the amount of overhaul are items which will affect a contractor's bid for the reason that these things will determine what kind of equipment he will use. If the work is heavy, having a large yardage concentrated in a short distance, warranting the installing of a steam shovel and industrial railway, he can afford to bid lower than if the same yardage is strung out over several times the distance in shallow cuts and fills, and containing much of what is known as pick and shovel work.

(5) Cost of materials, including cement, sand, crushed stone, reinforcing metal, etc., and the cost of labor. If the prices of these commodities are on the increase, it will be wise to add about 10 per cent to current prices for anticipated increase. It is very important to note whether such material as stone and sand are available along the road or must be shipped in from elsewhere. If stone is available locally, the cost of quarrying and crushing must be figured.

(6) The cost of water. This item is often left out of an estimate, although it may amount to a considerable sum. In the construction of a concrete road it is usually economical to deliver water through a pipe line. The unit cost will depend upon the length of pipe line, the size of pipe and the pressure required.

(7) Miscellaneous expense. In addition to the items of expense above enumerated, there are many others which vary widely with local conditions. Among these may be mentioned, loss due to unfavorable weather, muddy roads, inability to get materials, labor scarcity, equipment trouble, idle equipment and teams, and many other items which will figure in the final cost of the work regardless of whether it is done by contract or force account. Overhead expense of the contractor is presumed to be covered in his margin of profit, but engineering and superintendence must be added to the construction estimate to complete the total amount to be provided for the work.

Whether the work is to be done by contract or by force account, the accuracy of the preliminary estimate is equally important. In either case the cost will be governed largely by the conclusions of the preliminary study. It is within the province of the engineer to save money for the community in the proper location and economical construction of roads and the elimination of all needless costs, or, in other words, to provide as far as possible for the realization of the full value of every dollar expended. To accomplish this it is necessary to become so familiar with every condition affecting the ultimate cost that nothing of importance will be overlooked. The engineer should study his road as a physician studies his patient and then decide upon the proper treatment as a basis for the preliminary estimate. If it is necessary to guess on any obtainable information, guess high enough and err on the side of safety.

COST OF TOOTHING BRICK PAVING WITH AIR COMPRESSOR.

The Highways section of the Department of Public Improvements of Baltimore, Md., is using air compressors in connection with its work of toothing brick pavements. The following information on this work has been furnished us by R. M. Cooksey, City Highways Engineer. In doing this work by hand, stone cutters are employed in preference to laborers, this having been found to be more economical, as the latter class ruined much good paving. The average day's work for a stone cutter is 25 lin. ft. of toothing at $4.50 per day, which equals 18 ct. per ft. The average day's work by machine is 300 lin. ft. of toothing at a cost of $6.79 per day or $0.266 per ft. The cost of the machine work includes the following items:

5 gal. of gasoline	$1.05
1 gal. cylinder oil	.26
1 gal. Polarine oil	.23
1 special laborer	2.50
1 special laborer	2.75
Total	$6.79

The above prices are for 1916. It is expected that they will be slightly increased for the present year. The outfit used on this work is as follows:

One No. 2 portable compressed air outfit, with hose connections for hammers, purchased of Chris. D. Schramm & Son, Philadelphia, Pa., and two No. 2 Thor chipping hammers, purchased from the Independent Pneumatic Tool Co., New York. The city purchased three Thor hammers, so that it would have one in reserve, should the one in use get broken or out of order.

NOTES ON THE MAINTENANCE OF GRAVEL AND MACADAM ROADS.

Some interesting suggestions on highway maintenance were given by Mr. E. W. James, General Inspector, U. S. Office of Public Roads and Rural Engineering, in a paper presented Jan. 18 at a recent conference of the Virginia Good Roads Association. In his paper, an abstract of which is given below, Mr. James pointed out the difference between maintenance and reconstruction, and gave many useful hints on the patching of road surfaces.

When the gravel surface has been somewhat softened by rain the turf near the edge should first be run back with the grader. The surface may at the same time be scarified as much as may be necessary with a spike-tooth harrow or scarifier. New material should be added as required and the surface reshaped with a road machine. If this work is completed by using a road roller while the road is moist from recent rains, the result will justify the added cost.

Gravel roads may be patched as well as reworked, but they are a type that do not usually have patrol or gang maintenance forces and the customary procedure is to permit deterioration until a reworking is necessary. This may be most economical in some cases, but the precaution that should be taken is to see that the wear is taken up by the addition of new material. Too often top-soil and gravel roads are plowed deep with a plow and tractor and the loosened material reshaped without the addition of new. Of course this is not economical, because the amount of plowing is greater than would be necessary if new material were to be added, and plowing is ultimately required again when finally the replacement of surfacing material may no longer be postponed.

In patching gravel roads over small areas, to take up depressions that have formed, difficulty will usually be met in making the added material remain in place until compacted. The easist way to overcome this is to make the patch 4 to 5 in. thick, instead of an inch or two. The additional depth must, of course, be got by loosening the bottom of the old surface the required amount. This pad of material should be thoroughly rammed, especially at the edges, and left a little high. As soon as it has solidified under traffic any excess height should be trimmed down. With a good sand-clay gravel patches made in this way will stick in breaks in bituminous macadam surfaces. On experimental roads around Washington, U. S. Office of Public Roads patrolmen have successfully made such patches in winter when proper bituminous patches could not be made on account of temperature and moisture.

For a generally overloaded waterbound surface, one carrying too much automobile traffic or too many steel tired rigs, a general sanding is the easiest and most effective treatment. The sand is too heavy to make bad dust, and too hard and fine, and flows too easily to grind into a powder. It must be brushed back on the surface several times a season, depending on the traffic and the amount of rain. Such work may be required as often as once a week, and a skilfully handled grading machine is of course the best tool to use. When the work requires such frequent attention, however, it is about time to rebuild the waterbound macadam.

Patching waterbound macadam can only be satisfactorily done with a heavy roller. Unless such equipment is available there is little chance of making a good job. Stone of the proper size for each course patched should be laid and rolled and so far as possible the practice followed in construction should prevail. Each course of the patch should be compacted and locked securely before the adding of the next course. Final dressing should be accompanied by heavy sprinkling and a free use of chips and screenings. On account of the quantity and nature of equipment necessary the patching of waterbound macadam is usually neglected, and can in fact be done economically only when a considerable quantity has to be done.

The handling of surface treatment gives an opportunity to use skill and judgment of a high order in road maintenance. Some of the things that can be done with surface treatments in the face of heavy traffic, cold and variable winter seasons and bad foundations are surprising.

In general retreatments gravel covering or top dressing may be satisfactorily used and is ordinarily cheaper than stone chips. Gravel known as ⅝-in. stock material, that is, passing a ¾-in. mesh and retained on a ¼-in. mesh, is satisfactory for use on hot applications and on cold applications of 0.3 gal. or more. A torpedo sand passing a ¼-in. and retained on a ⅛-in. should be used for thinner application. It is possible on smooth surfaces to squeeze a treatment out as thin as 0.1 gal. per square yard. This means careful work and uniform handling, but the effect is worth it. Chips may always be substituted for ⅝-in. gravel and the size known as ½-in. stock is good. This product passes a ¾-in. screen and is free from dust. A larger chip may be used only if the treatment is rolled, but nothing larger than a ¾-in. chip should be used. A very soft limestone or granite ¾-in. chip may be used without the rolling, but in such cases the result is not as good as a harder and smaller chip would give.

When patches are made in surface treatment a cold patching material will be found satisfactory, for most all treatments, cold or hot. Stone chips and not gravel should be used for top dressing.

Water gas tar and coal tar may be used for patching the mat when the macadam below is not broken. The patches should be cleaned free of all loose material and dust, and the bitumen painted on with a stiff broom or brush. Even cold patching materials will work better if slightly warmed. Clean chips should be sprinkled over the patches at once and traffic can do the rest. We have found a coal tar having a rather high percentage of free carbon, about 18.5 per cent, has been of greater service in cold patching than a low carbon tar, because of the greater range of patch it may be used for. Holes from ½ to ¾ in. deep may be built up by successive patching until a true surface is reached, and with the coal tar there is little or no trouble with any flowing or pushing of the patch. Every break in the road surface should be patched. A good patrolman will take care of breaks only as large as a silver dollar if he is going over a section, to clean it up in good shape. It is unnecessary to say that he will take care of everything else.

Penetration patches must be used for breaks through a course of stone, or over about ¾ in. deep. Any good penetration material may be used, but care must be taken not to use too much. The stone in the patch cannot be compacted as the stone in a penetration course is under the roller, and in pouring on a patch a man is tempted to fill it flush with bitumen. If he does the patch will push and flow. Perhaps the best way to overcome this tendency is to make mixed patches. Have a fine wire basket that will hold any size from chips up. Make up a well assorted mix of stone sizes that will compact and dip and drain the whole thing. By using this material to tamp into the hole, even patches may be made without excess of binder and when topped with clean chips these patches may be tamped hard and firm.

Mixed surfaces may be patched in the same way as penetration surfaces.

Some time it is found that penetration work opens in fine check cracks, indicating some defect of foundations or surface construction. Two cases of this nature occurred last spring near Washington and as early as March a new seal coat of light coal tar with torpedo-sand-top dressing was successfully applied and served to hold the road.

In all reseal or surface treatment the use of a hard, durable top dressing will usually repay its careful selection. A penetration or mixed surface having an aggregate of granite, gneiss or sandstone, will be much improved, if the top dressing is a trap chip or hard waterworn gravel. Similarly a water-bound, surface treated macadam built of soft limestone will be made considerably more resistant to wear if a hard stone is used for top dressing.

The amount of covering used should not be excessive, —that is, it should not be so plentiful as to be wasted, or to reduce the percentage of bitumen in the mat to a point where it refuses to bind adequately. Care should be taken, however, to load the surface so evenly full of stone chips or gravel that it will have a mosaic rather than a cork-like or leathery texture.

The question of how many reseals or retreatments can be applied before the mat begins to shove is an open one. Reports made to the Office of Public Roads, chiefly based on judgment and not actual experience, by various State engineers, indicate that from three to four such treatments will be the practicable limit.

The U. S. Office of Public Roads has already laid in two cases, and three in several cases. On none of these sections is there so far any indication of shoving. The practicable limit doubtless depends very largely on the manipulation of the work. Leathery mats will doubtless build up much more rapidly than mosaic mats and hasten shoving. But if the retreatment is postponed, by the aid and control of careful routine maintenance of weak spots, so that the mat is practically worn away and the No. 2 stone is visible before any additional mat is placed, it appears likely that such surface can be held until foundation failure or increase of traffic demands changes in the surface.

NEW HAMPSHIRE PATROL SYSTEM FOR GRAVEL ROAD MAINTENANCE.

The State of New Hampshire has 966 miles of gravel roads built at any average cost of $3,900 per mile. The continuous system of maintenance is employed on much of this mileage, it having been the experience of the State Highway Department that the patrol system is indispensable for the proper care of gravel roads. The following description of the patrol system in this State is taken from a paper presented by Mr. F. H. Colburn, Division Engineer of the State Highway Department at the last annual short course in highway engineering at the University of Michigan:

The maintenance upon a gravel road is a continuous charge of so much per diem during the entire period when the road is exposed to traffic. There is no day when the patrolman employed upon a gravel road cannot be actively busy on the road and if he is busy each day there will be no time except, possibly, directly after several days' rain, when he is behind in this work.

New Hampshire has patrolmen on practically every inch of its trunk line roads and on a large number of its detached pieces of State aid road.

These men are paid from $3 to $3.50 per day and furnish a horse, cart and the hoe, shovel and small tools necessary for their work. On all gravel roads, the State furnishes a 1-horse split-log drag and on oiled roads a portable heater with which to do their patching. With 70 per cent of the roads gravel, which have not been treated with any bituminous material, of course, the main work of the patrolman is along lines of dragging and building up a road surface with local material. It is found that a good patrolman will keep about 6 miles of gravel road in perfect condition through the summer, and it also is found that it is much better to give this man enough road to allow for his steady employment rather than a limited number of days worked per week.

In some towns where the total length of the detached pieces of State aid road is so small that it will not warrant the steady employment of a patrolman the State Department has made arrangements to take over certain sections of town road. By adopting this method, it is able to give the patrolman enough road so that it is possible for him to give full time to road work. When a patrolman is only employed for two or three days per week, the road work is generally secondary to some other occupation, usually farming. Steady employment not only makes road work the man's primary occupation but also increases his efficiency. One of the pre-requisites of a good patrolman is pride in the section of road he patrols. This pride once brought out is of inestimable value to the good of the road. It often results in keen competition between patrolmen on adjoining sections. This competition spurs each on to greater efforts and better results.

The patrolmen in New Hampshire are required to make a daily report of their work and a weekly statement of their time and expenditures. By use of the daily report the State Highway Department is enabled to follow closely their work and to judge their capabilities.

On account of the lack of funds in maintenance as well as construction, the State is forced to adopt the most economic system of maintenance available. The patrol system is the result.

BROKEN STONE AND CONCRETE FOUNDATIONS FOR PAVEMENTS.*

In my judgment, the question of "best" or most "economical and efficient" pavement foundation (as to both character and depth) to meet any particular conditions necessarily entails a careful study and consideration of those conditions in each case, particularly including: Character of subsoil; character of traffic; character of wearing surface to be laid on the foundation; climatic conditions.

As a general statement, applied to new pavements—that is, streets or roads having no pavement or foundation which can be efficiently used as a foundation for a new wearing surface—I think a statement applied to this subject by the company with which I am associated, in its instructions or advice 15 years ago and maintained at all times since then, covers the ground as well as it could be covered in a few words, and is as follows:

> Sub-soil. An unyielding foundation is essential. Our specifications for bituminous base (Form B) are designed for characters of subsoil which can be rolled to provide a firm sub-foundation. Where unyielding sub-soil conditions do not exist, or where the roadway is so narrow or contains such obstructions as to make proper rolling of foundations impossible, the use of hydraulic concrete (Form C Specification) is recommended, being very careful that the concrete is roughened as specified. It frequently occurs and cannot always be foreseen that different portions of the same street, with a view to economy and utility, require different thicknesses as well as characters of foundation. For this reason it is advisable that specifications should provide for payment for the foundation per cubic yard, and prices for both bituminous and hydraulic concrete foundation.

In the 15 years which have elapsed since the formulation of that rule I have seen nothing to indicate that, as between crushed stone and hydraulic cement concrete foundation, it is not absolutely correct, except as noted below in the case of sandy subsoil under certain conditions.

In discussion of this matter I propose to consider "concrete" as including any dense aggregate ranging from coarse to fine, the particles of which are bound together by any cementing agent, whether hydraulic cement, bituminous cement or other cement. We will also consider that the question of use of broken stone foundation is practically limited to monolithic bituminous wearing surfaces.

Broken Stone Foundations.

Each individual case should be given special consideration with special reference to the character of subsoil and climatic conditions. If the subsoil is of the nature of clay and the climate such that the sub-base is liable to become wet before the waterproof pavement surface is laid, then it is unsafe to specify broken stone base because in such wet, yielding condition the subsoil does not provide a subgrade over which either the crushed stone or bituminous surface can be properly compressed.

If, on the other hand, the subsoil is of a gravelly nature, or if in a climate where it seldom or never rains during the working season, no more serviceable nor equally low-cost foundation can be produced for a stable bituminous wearing surface than a thoroughly rolled crushed stone.

This has been abundantly proven in many cases, of which I will cite two:

In El Paso, Tex., the subsoil is generally "caliche"—a sort of clay-bonded gravel—but sometimes gravel without the clay, and vice versa. Here during the past 10 years there has been laid a total of 586,000 sq. yd. of bitulithic pavement on 46 streets, and all of it on rolled broken stone base.

In Portland, Ore., the soil is generally clay or loamy clay, but in some cases gravel. Here bitulithic pavements have been laid during the past 12 years on 250 streets to the extent of 2,773,500 sq. yd.

In both cities many of the pavements are on heavy traffic business streets and the results in general are the peer of pavements of any type of wearing surface or base anywhere. Both cities are favored, from a construction standpoint, with comparatively dry weather during the construction season, so that the subgrade, once rolled solid, remains so throughout the process of construction, including the rolling of the crushed stone base and waterproof bitulithic wearing surface.

If, however, the subsoil is of a gravelly nature, through which water will drain with reasonable rapidity, the factor of dry climate becomes one of little importance in consideration of the type of pavement foundation.

Sand Subsoil.—Nearly 16 years ago we had great difficulty in securing a solidly compacted broken stone foundation on the sandy soil of one of the lake cities of Indiana. The spreading of marsh grass over the sandy subgrade before spreading the crushed stone helped immensely.

During the present year, however, we met an interesting case in connection with the building of bitulithic pavement on the "Interstate Bridge" crossing the Columbia River from near Portland, Ore., to Vancouver, Wash., and the bridge approaches. The bridge floor is 21,624 sq. yd. and the bitulithic pavement was laid on heavily reinforced Portland cement concrete foundation. The bridge approaches aggregate 46,320 sq. yd., or about 3 miles in length, and are formed of sand pumped from the Columbia River, the newly made fill thus made having depths varying from 5 ft. to 25 ft. Being washed in place, the sand fill is compressed as solidly as possible. The specifications required a broken stone base laid on this sand fill. The general belief is that under such conditions the crushed stone in rolling will compress several inches into the dry sand, and even then not be solidly compacted. It has, however, been proved that a generous amount of water used to wet the sand during the process of spreading and rolling the base provides a subgrade so solid that the stone compresses into it but very slightly and becomes solidly compacted under the 12-ton steam roller and, using the same heavy roller, no trouble develops in compression of the bitulithic wearing surface.

Here we have a useful application of the well-known scientific fact that on the beach dry sand cannot be traversed by the lightest vehicle, while sand combined with more water than will fill the voids in the sand will itself flow and not hold up the weight of a load. Sand from which the surplus water has drained away, leaving just enough water to fill the voids, will sustain a quite heavy load.

So on the bridge approaches the artificial application of water to the surface of the sand fill results in an excellent subgrade for broken stone foundation.

Economic utility of broken stone foundations is especially applicable in the case of old macadam country roads or city streets, the grade and contour of which are such that they can be regulated without serious disturbance of the old macadam.

It is a well-established fact that, with a dense, stable, waterproof pavement surface, rolled crushed stone base practically overcomes the cracking of Portland cement concrete. It is also self-evident that crushed stone foundation has the important economic advantage that in the case of broken stone base the bituminous wearing surface under pressure of the roller fills the chinks in the surface of the foundation and forms an important union between the foundation and surface which is impracticable in the long run with either Portland cement concrete or silicate of soda concrete foundations.

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*Abstract of a paper presented Dec. 28 before Section D of the American Association for the Advancement of Science by Geo. C. Warren, President of Warren Bros. Co., Boston, Mass.

Concrete Foundations.

These are divided into three general classes: Portland cement concrete; bituminous cement concrete; concrete bound together by other classes of cement.

We will consider this only on the basis of true concrete, as all concrete should be considered—that is, a dense mass of coarse and fine aggregate in which the coarse aggregates predominate and the fine aggregates are in approximately the proportion to fill the voids or air spaces between the coarser particles, approximately one-half to two-thirds of the total being coarse aggregate.

Sand Fill on Oregon Side of Interstate Bridge Approach.

If the cemented aggregate does not measure up to this test, then we have mortar, or at least a small percentage of coarse aggregate "floating" in a surplus of mortar, and not an "economical and efficient" concrete.

As previously stated, in cases of weak sub-base, solid dense concrete as described has an important advantage in that, by bridging over the weak sub-base, it imparts a greater strength than is possible with rolled crushed stone under such circumstances. Taking the subsoil conditions throughout the United States and Canada as a whole, in a large proportion of cases doubtless the subsoil and climatic conditions are such as to make the use of "concrete" desirable, but, as noted above, this is not at all a universal rule.

Crushed Stone Foundation, Interstate Bridge Approach.

Well-made Portland cement concrete base of the conventional proportions of 1 part cement, 3 parts fine aggregate and 6 parts coarse aggregate has a greater crushing and tensile strength than either broken stone or other types of concrete, but it is well established that a slab of Portland cement concrete laid on more or less damp subsoil will necessarily crack and, where cracks occur in the foundation, then cracking of the pavement wearing surface is sure to follow. In many cases such cracking is the lesser of two evils, and in such cases there can be no doubt but that Portland cement concrete is the best, and therefore the most economical and efficient pavement foundation, but this condition is not at all universal, nor even nearly so.

Bituminous concrete—i. e., concrete in which the well-proportioned coarse and fine aggregate, which may be either natural gravel and sand or crushed stone and sand heated and mechanically mixed with suitable bituminous cement and spread and rolled on the previously compacted subgrade—has the extremely important advantage of absolutely overcoming the cracking of Portland cement concrete foundations. It also has the at least equal, if not more important, advantage of a thoroughly united and unified foundation and surface, the two courses being of the same class of materials. The advantages are: (a) Retarding the tendency of the wearing surface slipping or shifting under traffic, either on the base or through the integral parts of the surface rolling on themselves. (b) Such a unified foundation and surface also permits the use of a somewhat thinner pavement, both as to surface and foundation, than is equally safe when the foundation and surface are of as widely different and non-unified materials as bituminous surface and either crushed stone or Portland cement concrete foundation.

In first cost of surface and foundation the difference depends chiefly on the local relative costs of Portland cement and suitable bituminous cements. Under the prices to which Portland cement has advanced during the past 2 years, there are many sections where pavements using bituminous concrete are lower in cost than Portland cement concrete, and in few places at this time is there any considerable advantage in cost of adequate surface and foundation in favor of Portland cement concrete.

Laying Bitulithic Surface on Interstate Bridge Approach.

During the past 5 years bitulithic city pavements and warrenite country roads have been laid on bituminous concrete foundation with uniform success in upwards of 30 municipalities of the United States and Canada to the extent of over 1,500,000 sq. yd.

Most of this work has been laid to a total depth of 5 in., 3½ in. of compressed bituminous concrete base and 1½ in. of compressed bitulithic or warrenite surface, but in some places an additional 1-in. depth of base has been used, making a total depth of 6 in.

During the past year the laboratory of the company with which I am associated has done a great deal of work investigating the use of silicate of soda as the cementing material for concrete foundations and finds that, in connection with a substantial waterproof bituminous wearing surface, which is also necessary to secure highest efficiency with Portland cement concrete, it is quite practicable to make high-grade concrete foundation in this way. The question is one of relative prices of Portland cement and silicate of soda and consequent first cost of construction. We have also successfully laid approximately 10,000 sq. yd. of wearing surface over concrete made of silicate of soda and crushed stone, which concrete had failed to successfully withstand vehicular traffic as a road surface in Cos Cob, Conn., and Sudbury, Ont. The silicate of soda concrete has greater resiliency and less rigidity than Portland cement concrete and apparently materially lessens, if it does not entirely overcome, the cracking of Portland cement concrete foundation.

CONTROL OF PAVEMENT OPENINGS.

Methods for the control of pavement openings in the city of New York were recommended by Mr. E. P. Goodrich, consulting engineer, New York City, in a paper presented Jan. 24 before the Citizens' Street Traffic Committee of Greater New York. An abstract of the paper follows:

The best way to treat a pavement opening is not to make it. In order to accomplish this end, several things have been worked out to advantage:

(a) Place sub-surface structures under sidewalks and grass strips. This is the German method, and has been demonstrated more efficient economically than the construction of pipe galleries.

(b) Whenever a pavement is to be replaced over a large area, all sub-surface structures should be renewed, or at least carefully examined and repaired; all house connections similarly treated, and the ground restored to as nearly virgin condition as possible under the new pavement. To secure this result, corporations owning subsurface structures should be notified in ample time to permit them to do this work. Householders should be notified to examine their structures, signs should be posted upon the street stating that the street is to be repaved, and sub-surface at structures must be carefully examined and prepared, and the fact further advertised by newspapers and handbills, if necessary. This practice was followed in the Borough of Manhattan for several years, but some of the corporations found that it was costing so much that they refused to continue the practice. The number of cuts in the new pavements increased perceptibly. Some effort should be made to force the corporations and property owners to make all needed repairs to their structures while the pavement is open. This may mean a revision of the franchise law, and it may mean a change of ordinance.

Except in cases of emergency, permits to open a newly-laid pavement should be rigidly refused. The period of such refusal might extend to several years. Hartford, Conn., is said to allow no openings in new pavements until after action by the City Council during a period of 10 years. Taking for granted that some cuts must be made, it is obviously essential to know where the sub-surface structures are actually located so that it will not be necessary (as is now often the case) that the corporation or the plumber will have to explore, making three or four openings in order to discover a leak.

This can be accomplished through an adequately financed and administered Bureau of Sub-Surface Structures. Starts toward such a bureau have been made in each of the boroughs in New York City, but their development has not yet been carried so far as to make the work of that department of very much importance except in Brooklyn.

Schemes should be devised to locate trouble through evidence secured from an examination of structures without making cuts for purely exploration purposes. Lately, the gas company has employed a device consisting of a pipe which they drive through the pavement and down into the ground as far as is possible or necessary, the opening produced by the removal of which is then examined for evidence of gas leakage. Formerly they made a cut large enough for a man to dig down to their pipe. Even the new device damages the pavement surface to a slight extent and the foundation surface to a greater extent. The hole produced by the pipe should be grouted through its full depth up to pavement surface and the latter carefully restored so as to secure a perfect surface.

In the case of water leaks, three or four schemes have been devised in various cities. One of these makes use of the water hammer. It is possible to locate a leak in a water main within a very few feet. The pressures at the water taps in the houses are also used. Still other varieties of exploration might be developed to advantage in the case of water mains. The same general scheme should be adopted and forced upon plumbers—to explore in a preliminary way before they cut the pavement.

Cuts in pavements should be allowed only upon the issuance of a permit containing certain rigid, explicit conditions. A cash deposit should be exacted to cover the cost of back-filling and pavement restoration, including inspection and clerical assistance, together with a proper sum to be held for a certain period, such as six months or a year, to guarantee proper workmanship on the part of the corporation or individual which did any work in a street. In other words, I would allow the corporation or plumber to backfill not to exceed 6 in. over the sub-surface structure, the remainder of the work to be made by the central official. In the case of a wood-block pavement, which when cut is apt to expand and depreciate the pavement accordingly, a restoration might be specified to include the installation against the sides of the blocks of heavy timbers, with screw-jacks employed to keep the pavement in its old tense state. Back-filling should be covered by ordinance, coupled with a heavy fine, if the specifications are not followed or the work is found deficient. Three-in. layers tamped hard and smooth before the next layer is installed I believe not a too rigid specification, as is well known. If a 6-in. thickness is specified, the usual method is to put in 12-in. or 15-in. While even with a 3-in. specification layers 6 in. in thickness will actually result.

The specification for tamping should be equally explicit, limiting the amount which a given weight on the end of a 4x4 timber should sink into the tamped surface. After such back-filling and hard tamping, concrete should be installed for a foundation in all cases except perhaps in that of macadam, including cases in which the original foundation was of blocks or separate elements. Such a concrete restoration should extend over the untouched earth sides 6 in., or possibly more, the amount to be determined by the chief engineer. The wearing surface should be replaced still further back on the old foundation material. In the case of pavements, like wood block, brick or granite, in which there is a sand cushion, the sand should be tamped hard. The usual method is simply to sprinkle in some loose sand and strike it off; then the blocks should be tamped equally hard. In the case of wood block, for example, when the surface is replaced according to common practice there will be a rough edge, over which every vehicle bumps to a certain extent. This is usually due to the fact that new blocks are used to replace those which have been worn down to a slight extent. The obvious remedy is to employ specially cut blocks of proper depth to fit the old work.

Wherever deemed necessary by the chief engineer, the concrete foundation should be increased in thickness and steel reinforcement installed. Other cities have demonstrated the advisability of such action and New York should follow their example. In any event, the joint between the old and the new concrete and the old and the new wearing surface should be most carefully bonded.

In certain cases, the ordinances should give the chief engineer power to enforce night work, so that the day condition after planking will allow traffic to move freely on such avenues as Fifth Avenue, Broadway in Manhattan, Broadway in Brooklyn, and other such congested districts. It is also wise to place planks over the opening while the fresh concrete is hardening. In London, for example, they actually block off the opening for a period of a week or more until the concrete is hardened. Here in Manhattan we are likely to restore the final surface too early, so that the concrete crushes under traffic and a slight depression in the pavement results.

The back-filling and pavement restoration should be done exclusively under the direction of the official responsible for street surfaces. The wearing surface may, under some circumstances, best be installed by pavement companies, but the remainder of the work in almost every instance can best be done by city day labor under efficient technical supervision.

STANDARD PAVEMENTS FOR LOS ANGELES, CAL.

For the information of property owners and other interested parties the Engineering Department of Los Angeles, Cal., has issued a circular containing an abstract of the standard pavements of that city. The summary, which is reprinted below, gives the types of surfacings considered by the department as best suited to conditions of traffic, soil and grades. The estimated costs are for the pavements on streets already graded and do not include extensive cuts or fills, the cost of which will be additional. Neither do the estimates include the cost of culverts, storm sewers, catch basins, gutters at intersections, etc., which may be necessary.

Asphalt (Specifications No. 96).—These specifications embrace pavements designed for heavy, medium and light traffic.

That for heavy traffic consists of a 6-in. base of 1:3:6 cement concrete with a 1½-in. or 1-in. binder and a 1½-in. or 2-in. sheet asphalt wearing surface, making a total thickness of 9 in., and its approximate cost is 18 ct. per sq. ft. This pavement is suited to heavy traffic, on all soils and on grades of not over 5 per cent.

That for medium traffic consists of a 5-in. base of 1:3:6 cement concrete, a 1-in. binder and a 1½-in. or 2-in. sheet asphalt wearing surface, making a total thickness of 8 in., and its approximate cost is 17 ct. per sq. ft. This pavement is suited to medium traffic, on all soils and on grades of not over 5 per cent.

One pavement for light traffic, under Specifications No. 96, consists of a 4-in. base of 1:3:6 cement concrete, a 1-in. binder and a 1½-in. sheet asphalt wearing surface, making a total thickness of 6½-in., and its approximate cost is 16 ct. per sq. ft. This pavement is suited to light traffic, namely in residence streets, on all soils, and on grades of not over 5 per cent.

Another pavement for light traffic, under Specifications No. 96, consists of a 3-in. asphalt or bituminous base and a 1½-in. sheet asphalt wearing surface, making a total thickness of 4½ in., and its approximate cost is 12 ct. per sq. ft. This pavement is suited to very light traffic, and on grades of not over 5 per cent, and only on firm soils.

Asphalt Concrete ("Topeka" Specifications No. 94).—This pavement is designed for light traffic and consists of a 4-in. base of 1:3:6 cement concrete with a 1½-in. "Topeka" asphalt concrete wearing surface, making a total thickness of 5½ in., and its approximate cost is 15 ct. per sq. ft. This pavement is suited to light traffic on grades of not over 6 per cent, and on all soils.

Alphalt Concrete ("Topeka" Specifications No. 102).—This pavement is designed for light traffic and consists of a 3-in. base of asphalt or bituminous concrete and a 1½-in. "Topeka" asphalt concrete wearing surface, making a total thickness of 4½ in., and its approximate cost is 10 ct. per sq. ft. This pavement is suited to light traffic on grades of not over 6 per cent and on firm soils.

Bitulithic (Specifications No. 99).—These specifications embrace pavements of three different thicknesses of base designed for heavy, medium and light traffic.

That for heavy traffic consists of a 6-in. base of 1:3:6 cement concrete, a 2-in. bitulithic wearing surface making a total thickness of 8 in., and its approximate cost is 20 ct. per sq. ft. This pavement is suited to heavy traffic on all soils and on grades of not over 6 per cent.

That for medium traffic consists of a 5-in. base of 1:3:6 cement concrete, a 2-in. bitulithic wearing surface, making a total thickness of 7 in., and its approximate cost is 18 ct. per sq. ft. This pavement is suited to medium traffic on all soils and on grades of not over 6 per cent.

That for light traffic consists of a 4-in. base of 1:3:6 cement concrete, a 2-in. bitulithic wearing surface, making a total thickness of 6 in., and its approximate cost is 16 ct. per sq. ft. This pavement is suited to light traffic, namely, on residence streets, on all soils and on grades of not over 6 per cent.

Bitulithic (Specifications No. 97).—These specifications embrace pavements of two different thicknesses of base designed for medium and light traffic.

That for medium traffic consists of a 4-in. bituminous base, a 2-in. bitulithic wearing surface, making a total thickness of 6 in., and its approximate cost is 15 ct. per sq. ft. This pavement is suited to medium traffic, on grades of not over 6 per cent, and only on firm soils.

That for light traffic consists of a 3-in. bituminous base, a 1½-in. bitulithic wearing surface, making a total thickness of 4½ in., and its approximate cost is 14 ct. per sq. ft. This pavement is suited to light traffic, namely, in residence streets, on grades of not over 6 per cent, and only on firm soils.

Concrete (Specifications No. 101).—These specifications embrace pavements of two different thicknesses of base, designed for medium and light traffic.

That for medium traffic consists of a 6-in. base of 1:2:3½ cement concrete with no other wearing surface, and its approximate cost is 16 ct. per sq. ft. This pavement is suited to medium traffic on streets and wide alleys, on all soils and on grades of from 6 per cent to 12 per cent.

That for light traffic consists of a 5-in. base of 1:2:3½ cement concrete with no other wearing surface, and its approximate cost is 14 ct. per sq. ft. This pavement is suited to light traffic in streets and alleys, on all soils and on grades of from 6 per cent to 12 per cent.

Granite Block (Specifications No. 59).—These specifications embrace pavements for heavy, medium and light traffic.

That for heavy traffic consists of a 5-in. base of 1:3:6 cement concrete, a 2-in. sand cushion and a wearing surface of 6-in. granite blocks, making a total thickness of 13-in., and its approximate cost is 45 ct. per sq. ft. This pavement is suited to heavy traffic on all soils and all grades.

The granite block pavement designed for medium and light traffic consists of a rolled natural soil base, a 2-in. sand cushion, and a 6-in. granite block wearing surface, making a total thickness of 8 in., and its approximate cost is 37 ct. per sq. ft. This pavement is suited to medium and light traffic on grades varying from 6 per cent to 20 per cent.

Macadam (Specifications No. 83).—This pavement is designed for medium traffic and consists of a 4-in. base of broken stone with a 2-in. wearing surface of broken stone screenings and oil, making a total thickness of 6 in., and its approximate cost is 11 ct. per sq. ft. This pavement is designed for medium traffic of not over 12 per cent, and the best results are obtained on firm soils. On light sandy soils this pavement is not satisfactory.

Protected Concrete (Specifications No. 100).—These specifications embrace pavements of two different thicknesses of base designed for medium and light traffic.

That for medium traffic consists of a 6-in. base of 1:2:3½ cement concrete with a ¼-in. heavy oil wearing surface, making a total thickness of 6¼ in., and its approximate cost is 16½ ct. per sq. ft. This pavement is suited to medium traffic on all grades of not over 6 per cent and on all soils.

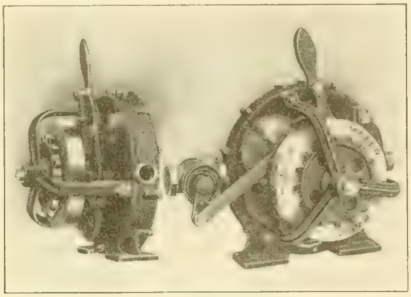
That for light traffic consists of a 5-in. base of 1:2:3½ cement concrete with a ¼-in. heavy oil wearing surface, making a total thickness of 5¼ in., and its approximate cost is 14½ ct. per sq. ft. This pavement is suited to light traffic on all grades of not over 6 per cent and on all soils.

Vitrified Brick (Specifications No. 90).—This pavement is designed for medium and light traffic and consists of a 4-in. base of 1:3:6 cement concrete with a 1½-in. sand cushion and a 4-in. vitrified brick wearing surface, making a total thickness of 9½ in., and its approximate cost is 28 ct. per sq. ft. This pavement is suited to medium and light traffic, on grades of from 6 per cent to 12 per cent and on all soils.

Warrenite Pavement on a Bituminous Base (Specifications No. 103).—This pavement is designed for light traffic and consists of a 3-in. bituminous base and a 1½-in. Warrenite wearing surface, making a total thickness of 4½ in., and its approximate cost is 12 ct. per sq. ft. This pavement is suited to light traffic on grades of not over 6 per cent and on firm soils.

AUTOMATIC WATER REGULATOR FOR CONCRETE MIXING.

A device for the automatic regulation of water for mixing concrete has been placed in the market recently by the Municipal Engineering & Contracting Co., Chicago, Ill. This regulator is driven by a sprocket and chain attached to some moving shaft on the mixer and its action is similar to that of a positive vane pump. The quality of water discharged is indicated by an indicator lever and dial showing the number of gallons for which the meter is set. The regulator is rated to discharge from 1 to 20 gal. in 10 seconds, and can be connected to a pipe line or it will draw water from an open tank under a suction lift of several feet. The device is known as the Austin automatic regulator and meter.



Austin Automatic Regulator and Meter.

STREET CLEANING METHODS AND COSTS IN THE DISTRICT OF COLUMBIA.

The per capita cost of street cleaning in the District of Columbia for the fiscal year ended June 30, 1910, was 83.1 ct. Over two-thirds of the expenditure was for hand patrol work and washing. The following outline of the street cleaning method is taken from the report of Mr. J. W. Paxton, Superintendent of Street Cleaning, in the recently issued report of the Operations of the Engineer Department of the District.

Machine Sweeping.—This work covers all paved streets outside hand patrol area. It is done daily, every other day, or every third day, depending on location and traffic. Two gangs are employed, the total force and equipment being as follows: 3 2-horse sprinklers, 9 2-horse brooms, 11 1-horse carts and 12 broom men. The actual number of 8-hour days the machine brooming force worked in the last fiscal year was 273.4. This takes in all paved alleys in the District of Columbia. The cleaning is done about once each week. Alleys in the business section with heavy traffic are cleaned twice each week. The force consists of three gangs, totaling 3 1-horse sprinklers, 2 1-horse brooms, 11 1-horse carts and 17 broomers. The actual number of 8-hour days worked last year was 273.6 and the total area under attention was 1,120,095 sq. yd.

Hand Patrol—All streets in the central portion of the city are cleaned in this way from 1 to 8 or 10 times each day; depending on location and traffic. The work is done by six gangs, totaling 14 2-horse wagons and 271 white wings. The actual number of 8-hour days worked was 285.8, and the total area under attention was 3,731,092 sq. yd.

Squeegeeing.—Nearly all the smoothly paved streets in the hand patrol are squeegeed, the interval of cleaning being about every 2 days in summer and three in winter. The dirt is removed by hand patrol. The force consists of three gangs, totaling 3 2-horse sprinklers, 12 2-horse squeegees, and 1 3-horse squeegee. In all 245.8 8-hour days were worked, the area under attention consisting of 2,353,058 sq. yd.

Flushing.—This is done on cobblestone, granite, asphalt block, and poorly paved streets in hand patrol district. The interval of cleaning is short, every three days. The dirt is flushed to the gutter and removed by the hand patrol. The flushing force consists of one gang of 3 3-horse pneumatic type flushing machines. The total number of 8-horse days worked was 261.2, and the area flushed was 341,622 sq. yd.

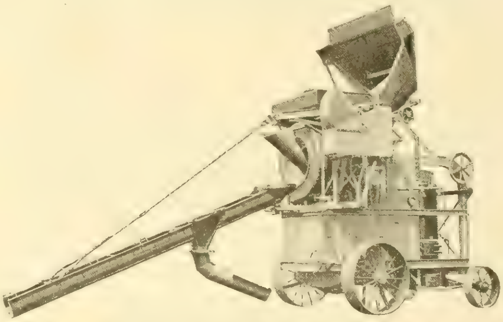
The comparative costs of street cleaning per 1,000 sq. yd. by the methods outlined above in the years 1912 to 1916 were as follows:

	1912.	1913.	1914.	1915.	1916.
Hand patrol	$0.152	$0.154	$0.140	$0.132	$0.132
Machine sweeping	.162	.161	.156	.149	.144
Alley cleaning	.324	.325	.337	.331	.326
Squeegeeing	.096	.117	.121	.115	.106
Flushing	.272	.248	.232	.194	.212

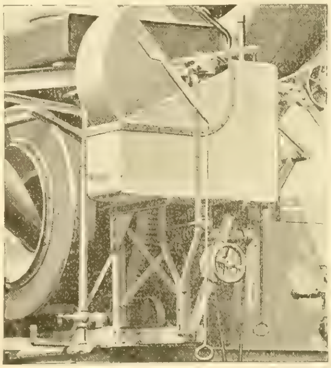
Changes and improvements in methods of measuring and distribution prevent exact comparison between the figures for different years. The above costs include only labor pay rolls; forage, shoeing and other stable expense; supplies, such as brooms, shovels, etc.; and repairs to equipment.

SMITH-CHICAGO HIGH DRUM MIXER AND ITS WATER MEASURING DEVICE.

The accompanying illustrations show the new type Smith-Chicago high drum paver and the automatic water measuring device with which the mixer is equipped. This device accurately measures the necessary amount of water for each batch and then automatically pours it into the drum, through the feed opening along with the unmixed batch from the skip. The amount of water can be regulated by sliding a weight along a balance arm until it reaches a notch corresponding to the number of gallons desired. There also is a storage tank holding water enough to take care of seven batches of concrete, thus obviating the necessity of stopping in mixing if the water supply should be stopped temporarily by breakage of the pipe line or for other reasons. The mixer is made in three sizes: 7, 10 and 14 cu. ft. mixed batch capacities. It is manufactured by the T. L. Smith Co., Milwaukee, Wis.



Smith-Chicago High Drum Paver.



Automatic Water Measuring Device.

STATISTICS OF PAVEMENT CONSTRUCTION IN 1916 IN THE UNITED STATES.

Amounts, Unit Prices and Details of Asphalt, Bithulithic, Bituminous Concrete, Brick, Concrete, Stone Block and Wood Block Paving Laid Last Year in Various Cities, Also Prices of Labor and Materials.

TABLE I.—MILEAGE OF PAVEMENT LAID IN 1916 IN A NUMBER OF CITIES AND MILEAGE OF PAVEMENT PROPOSED FOR 1917.

	Pavement laid in 1916. Miles.	Pavement laid in 1916. Cost.	Pavement contemplated for 1917. Miles.	Pavement contemplated for 1917. Cost.
New England Division:				
Maine—				
Biddeford	...	$27,000	...	...
Portland	1.30	30,441	...	...
New Hampshire—				
Keene	?	?	?	?
Laconia	?	?	?	?
Vermont—				
Bennington	?	?	?	?
Burlington	?	?	?	?
Montpelier	?	?		?
Massachusetts—				
Adams	...	18,000	...	$5,000
Arlington	...	...	...	...
Brookline	...	...	...	65,000
Cambridge	14.3	...	...	...
Everett	...	...	...	...
Greenfield	¾	...	1	...
Haverhill	4.4	74,062	?	?
Lawrence	47/100	...	3.5	20,000
Lowell	...	...	...	...
Lynn	32.68	...	...	...
Malden	...	...	...	...
Marlboro	...	71,435	4,000	5,000
Newton	...	40,000	...	40,000
Peabody	...	...	...	29,000
Revere	...	...	...	40,000
Somerville	6.1	...	...	...
Springfield	...	...	...	...
Watertown	1½	23,835	...	...
Westfield	...	...	...	...
Connecticut—				
Ansonia	...	...	...	17,000
Bridgeport	15.80	491,635	20	600,000
Derby	...	...	...	4,500
Hartford	2	59,022	2¾	133,000
Manchester	...	...	...	...
New Haven	...	...	...	...
Stamford	...	...	...	...
Willimantic	...	...	...	...
Rhode Island—				
Providence	...	...	...	...
Woonsocket	...	...	?	?
Middle Atlantic Division:				
New York—				
Albany	8.5	312,512	6.4	250,000
Batavia	1½	55,000	...	10,000
Corning	...	...	...	...
Elmira	2.398	108,821	1.75	83,300
Fulton	½	12,000	1½	60,000
Gloversville	...	16,026	...	...
Hudson	1½	45,000	...	...
Johnstown	.03	...	.80	34,591
Little Falls	1	38,000	?	...
Lockport	...	...	...	...
Middletown	⅓	...	...	...
Newburgh	...	17,083	...	...
Norwich	¼	8,800	...	...
Ogdensburg	...	...	...	...
Olean	12/100	4,500	2	85,000
Oneida	.312	...	...	...
Oneonta	...	...	...	...
Oswego	5.5	27,573	6	34,000
Port Jervis	27/100	13,400	...	...
Portchester	...	...	1	35,000
New Jersey—				
Bayonne	4 6/10	226,368	4 5/10	250,000
Bloomfield	...	...	2	130,000
Burlington	...	...	...	...
Hackensack	...	12,616	...	...
Harrison	...	...	...	...
Millville	...	...	...	...
New Brunswick	...	256,967	...	...
Passaic	.94	32,700	1.1	17,000
Phillipsburg	...	...	2.6	150,000
Plainfield	...	...	...	...
Ridgewood	...	8,000	3.7	160,000
Westfield	2	29,000	2	15,000
Pennsylvania—				
Altoona	3.997	132,088	6.6	225,000
Bradford	...	21,366	...	90,000
Carbondale	...	...	...	85,000
Chambersburg	...	...	...	...
Easton	...	...	...	...
Erie	1 7/10	66,774	4	250,000
Farrell	...	23,065	...	26,250
Franklin	...	...	...	27,000
Greensburg	.980-	16,472	.6	...
Greenville	...	...	½	...
Harrisburg	1.371	31,898	1.000	8,000
Jeanette	.617	17,698	.8	...
Boro of Juniata	.7	21,669	1.12	41,920
Lansford	...	...	...	...
Lock Haven	...	...	...	...
McKees Rocks	...	...	...	
Monongahela City	...	5,371	...	...
Boro of New Brighton	¼	3,599	...	...
New Castle	2	81,000	2	...
Norristown	½	...	½	...
Northampton	...	...	...	...
Oil City	.06	3,168	1	30,000
Pittstown	½	19,304	...	
Scranton	2.09	84,876	6	253,853
Shamokin	...	...	...	...
So. Bethlehem	.45	9,788	...	150,000
WilkesBarre	2.64	110,000	3	125,000
Williamsport	.053	...	.64	...
York	.52	27,674	...	...

TABLE II.—AMOUNT AND DETAILS OF BRICK PAVEMENT LAID IN 1916 IN VARIOUS CITIES.

	Square yards.	Kind of filler.	Depth of sand cushion, in.	Av. price per sq. yd., including base and grading.	Guarantee, years.	Price per cu. yd. for grading if paid separately.	Total thickness pavement, in.	Concrete base. Thickness, in.	Concrete base. Proportions.
New England Division:									
Vermont—									
Montpelier	308	......	...	....	..	....	....	..	....
Massachusetts—									
Adams	...	Grout	1½	$2.91½	5	$0.59	10½	5	1:2½:5
Somerville	4,720	Cement	[1]1	2.80	..	....	9	4	1:3:6
Springfield	7,260	Pitch[2]	¾	2.97	..	....	....	5	1:3:6
Middle Atlantic Division:									
New York—									
Batavia	20,000	Cement	1½	2.20	5	....	11½	6	1:2½:5
Elmira	13,973	Grout	1½	2.35	5	...	....	7	1:2½:5
Elmira	14,400	Pitch	1½	[3]2.31	5	...	....	7	1:2½:5
Hudson	...	Cement	[4]1	2.60	..	...	....	[illegible]	....
Little Falls	684	Cement	1½	*2.54	5	.57	11½	5	1:2½:5
Lockport	3,500	Cement	2	2.65	5	...	12	6	1:2:4
Olean	1,770	Grout	1½	*2.16	2	.70	10½	5	1:2½:5
Oswego	5,834	Cement	[1]1	*2.05	5	[illegible]	8	5	1:3:6
Port Jervis	4,210	Grout	1½	*2.40	2	.70	10½	5	1:3:6
New Jersey—									
New Brunswick	8,440	Grout	2	2.65	5	...	10	5	1:3:6
Ridgewood	12,000	Cement	2	*2.10	10	.2	12	6	1:3:6
Ridgewood	6,000	Cement	2	*1.90	10	.26	10	4	1:3:6
Pennsylvania—									
Altoona	60,350	Grout	1	·2.19	5	....	[5]9	[5]4	1:3:6
Bradford	6,384	Grout	1	*2.30	1	.70	11	6	1:3:6
Carbondale	32,000	Grout	1½	*1.91	5	.15	9½	4	1:2½:5
Erie	2,645	Cement	1	1.65	5	...	8	4	1:2½:7
Farrell	14,500	Pitch	[1]1	1.59	..	...	15	..	....
Greensburg	[7]8,589	Sand	1	1.46	1	.58	12	..	....
Greensburg	[8]2,727	Sand	1	1.44	1	.58	12	..	....
Jeanette	†10,724	Sand	1	*1.65	.	.40	12	..	....
Juniata	2,975	Grout	2	2.35	5	...	12	6	1:2½:5
Lancaster	3,537	Asphalt	1	2.75	2	...	11	6	1:3:6
Monongahela City	2,370	Sand	1½	1.95	..	.75	[10]12	..	....
New Brighton	...	Sand	2	*1.60	..	.65	....	..	....
New Castle	[11]	Cement	2	1.95	5	....	11½	6	1:3:7
Norristown	2,400	Grout	1½	...	..	...	10	4½	1:2:4
Oil City	728	Cement	1½	*2.32	5	.70	10½	5	[illegible]
Pittston	3,467	Asphaltum	2	2.34	5	....	12	6	1:3:5
Shamokin	...	Grout	2	2.54	5	....	12	6	1:2:5
Wilkes-Barre	3,243	Cement	2	2.25	5	.50	....	6	1:3:6
Williamsport	...	Cement	2	2.35	1	....	12	6	1:3:7
Maryland—									
Baltimore	15,736	Cement	[1]1	*2.25	5	.87	....	[12]6	[illegible]
East North Central Division:									
Ohio—									
Alliance	35,000	Cement	1½	1.80	1	...	10½	5	[illegible]
Bellefontaine	1,800	Grout	1½	*1.95	..	.40	....	6	1:3:6
Cincinnati	8,200	......	1	2.35	2	..	....	..	1:3:6
Columbus	124,000	Cement	1½	1.77	5	[illegible]	11½	6	1:3½:7
Dayton	39,600	Cement	1	1.82	5	.	11	6	1:3:6
Delaware	5,600	Cement	2	*1.76	..	.27	12	6	1:3:6
East Liverpool	[15]2,513	Sand	2	1.58	1	.55	....	..	......
Elyria	9,350	......	2	*2.06	2	.50	11	5	1:3:5
Ironton	[16]16,641	Grout	1½	*1.13	5	....	....	..	....
Lancaster	20,936	Sand	1½	*.93	½	....	[17]12	..	....
Lima	36,367	Cement	1½	*1.95	..	.45	11½	6	1:3:6
Mansfield	7,634	Asphalt	1½			...	9½	4	1:2½:4
Marietta	21,152	Sand	2	1.32	5	...	....	..	....
Massillon	3,750	Tar	2	1.75	1	....	11	7	1:3:6
Newark	30,511	Grout	1	1.60	1	...	9	4	1:6
Painesville	17,280	Grout	1½	*1.64	.	.35	10½	5	1:2½:5
Portsmouth	9,931	Tar	2	1.45	2	.40	12	6	1:3:6
Sandusky	35,040	Grout	1½	*2.00	3	.70	11½	6	1:3:6
Steubenville	9,860	Cement	1½	*1.63	1	.60	...	4	1:2:6
Urbana	19,619	Cement	1½	1.85	5	....	11½	6	1:3:6
Urbana	8,141	Mastic	1½	2.01	.	...	11½	6	1:3:6
Youngstown	46,192	Cement	2	*1.64	2	.40	18	5	1:3:6
Zanesville	21,378	Cement	1½	*1.70	.	.40	11½	6	1:2½:5
Indiana—									
Evansville	14,950	Cement	1	1.61	.	.	11	5	1:3:6
Fort Wayne	21,005	Cement	2	*1.79	.	.48	12	6	1:3:6
Frankfort	14,957	Cement	1½	*1.72	.	.4	8½	4	1:2½:5
Goshen	14,668	Cement	1	1.86		.40	11	..	....
Huntington	5,231	Pitch	1½	2.30	.	.	11½	6	1:2½:5
Portland	33,000	Cement	2	1.80		.25	11	..	....
South Bend	1,168	Sand	1½	*1.53			10½	..	....
Illinois—									
Chicago Heights	50,000	Grout	[illegible]	2.12			12	6	1:3:6
Decatur	[illegible]	Grout	1	*1.78		.	10	5	1:4:4
Kankakee	24,500	Grout	2	.	1	.6	12	6	1:3:5
Mattoon	32,200	Grout	1½	[illegible]		.50	10½		....
Ottawa	14,000	Grout	2	[illegible]			10	4	1:3:6
Peoria	48,044	Grout	[illegible]	*1.60		2	11	5	1:3:6
Pontiac	7,266	Grout	2	[illegible]	2	[illegible]	10	4	1:2½:5
Rockford	...	Asphalt	1½	*1.84	.	.37	10½		1:3:6
Michigan—									
Ann Arbor	11,600	Grout	1	*2.06	.	.70	11	6	1:2½:5
Battle Creek	8,403	Cement	1½	1.76		.	12		1:8
Bay City	700	Grout	2	*1.70		[illegible]		5	1:3:5
Flint	3,620	Cement	1½	*2.06		.47	11½		1:2:5
Grand Rapids	54,003	Grout	1½	*1.90	.	.40	10½	5	1:3½:7
Ionia	3,800	Cement	1	1.30	.	[illegible]	11	.	1:3:6
St. Joseph	7,240	Cement[22]		1.70	5	....	12	.	1:2:4
Wisconsin—									
Appleton	11,100	Grout	1	2.25			11		1:3:6
La Crosse	3,521	Asphalt	2	2.20			10½		[illegible]
Oshkosh	4,124	Cement		2.48		...	.		..
Sheboygan	3,767		.	2.10	0	.	10	.	1:3:5
Stevens Point	14,225			*1.32		.25	..		...
West North Central Division:									
Minnesota—									
Duluth	73,839	Cement	1½	*2.26	5	.71	11½	.	1:3:6
St. Paul	10,049	Asphalt	1½	2.68	5	...	10½		1:3:5

TABLE II.—AMOUNT AND DETAILS OF BRICK PAVEMENT (Continued).

	Square yards.	Kind of filler.	Depth of sand cushion, in.	Av. price per sq. yd., including base and grading.	Guarantee, years.	Price per cu. yd. for grading if paid separately.	Total thickness pavement, in.	Concrete base. Thickness, in.	Concrete base. Proportions.
Iowa—									
Dubuque	39,000	Asphalt[24]	1½	2.05	0	....	9	5	1:3:5
Keokuk	1,936	Asphalt	2	1.83	2	.60	10	4	1:2:4
Marshalltown	2,227	Asphalt	1½	2.28	1	.40	10½	..	1:3:6
Muscatine	8,088	Asphalt	1	1.86	5	....	9	4	1:6
Missouri—									
Joplin	6,300	Asphalt	1	1.71	0	....	5	5	1:6
Sedalia	12,295	Asphalt	...	....	..	....	..	....	....
Kansas—									
Atchison	12,000	Asphalt	1½	1.95	5	.35	9	4	1:2½:5
Independence	[25]7,833	Asphalt	1½	*1.45	..	.38	10	..	....
Topeka	[26]12,000	Asphalt	2	*1.97	..	.42	11	5	1:2½:5
Topeka	[27]34,000	Asphalt	2	*1.77	..	.42	10	6	1:2½:5
Wichita	34,211	Asphalt[24]	1	*1.95	2	.43	9	5	1:3:5
Nebraska—									
Fremont	20,809	......	1½	2.04	1	....	8½	4	1:3½
York	[25]26,000	Asphalt	1½	2.02½	5	....	8½	4	1:5½
South Atlantic Division:									
West Virginia—									
Clarksburg	[1]8,000	......	...	2.75	..	....	10	5	1:2½:5
Huntington	124,019	Sand	2	1.48½	5	....	12	..	....
Moundsville	5,096	Cement	2	*1.32	..	.35	....	..	1:2½:5
Morgantown	[28]45,000	......	...	*2.50	5	.60	10¾	5½	1:2½:5
Parkersburg	[29]40,857	Grout	1	*1.73	5	.40	10	5	1:2½:5
East North Central Division:									
Kentucky—									
Frankfort	7,000	......	..	2.24	2	....	11½	6	1:2:4
Louisville	59,758	Cement	1½	*1.81	5	....	....	6	1:3:6
Tennessee—									
Jackson	...	......	...	2.05	5	....	9	4	1:6
Memphis	5,694	......	...	....	..	....	....	6	1:2:5
Mississippi—									
Vicksburg	19,269	Grout	1½	*2.00	5	.50	8	4	1:3:5
West South Central Division:									
Louisiana—									
Lake Charles	5,000	Grout	1½	2.20	5	....	9½	5	1:3.6
Texas—									
Austin	1,779	Asphalt	...	....	..	....	....	..	....
Mountain Division:									
Montana—									
Helena	1,600	Grout	2	*2.65	7	.50	9	5	1:3:5
Pacific Coast Division:									
California—									
Los Angeles	1,800	......	2	2.70	..	....	11	5	....

*Does not include grading. †By city forces. [1]Sand and cement mixed. [2]Pitch, cement, sand. [3]5-in. $2.31, balance, $2.86. [4]Mortar cushion. [5]9 in.-11 in. 4 in. to 6-in. base. [6]Slag cushion. [7]On streets, 7-in. slag base. [8]On alleys, 7-in. slag base. [9]7-in. slag base. [10]Include 6½-in. slag base. [11]Two miles. [12]4-in. and 6-in. [13]Granulated slag. [14]35 ct. to $1. [15]On 8-in. gravel base. [16]On old macadam base. [17]Including 8-in. gravel and sand base. [18]10-in., 11-in. or 12-in. with 4-in., 5-in. or 6-in. concrete base. [19]Includes 6-in. gravel base. [20]1-in. and 2-in. [21]10-in. and 11-in. with 4-in. or 5-in. concrete base. [22]Cement and pitch. [22]Monolithic. [23]On natural base; 9,356 yds. at $1.32, balance $1.52. [24]Asphalt and cement. [25]Fibre block. [26]4-in. brick 18%. [27]3-in. brick 20%. [28]Semi-monolithic. [29]$1.60 on 4-in. base; $1.73 on 5-in. base.

TABLE I.—MILEAGE OF PAVEMENT (Continued).

	Pavement laid in 1916. Miles.	Pavement laid in 1916. Cost.	Pavement contemplated for 1917. Miles.	Pavement contemplated for 1917. Cost.
Maryland—				
Baltimore	?	?	?	?
Frederick	....	4,645	.....	18,355
East North Central Division:				
Ohio—				
Alliance	....	63,000	1	....
Bellefontaine	½	16,326	.....	....
Bellaire	....	....	.....	....
Cincinnati	7.8	520,608	.....	....
Columbus	15.344	695,602	10	500,000
Conneaut	.6	31,320	1.4	65,500
Dayton	4.06	215,250	10	680,000
Delaware	....	....	¾	....
East Liverpool	....	18,347	.....	....
Elyria	....	....	.....	....
Fostoria	....	....	.....	....
Ironton	1 1/10	21,511	½	10,000
Lancaster	1.14	26,109	.71	19,300
Lanesville	1.51	51,609	2.63	140,246
Lima	5.23	232,580	7	275,000
Mansfield	1.267	58,231	.....	....
Marietta	3.65	59,934	2	....
Massillon	1	16,000	½	20,000
Middletown	....	....	.....	....
Newark	3.527	102,860	3.5	125,000
Painesville	1.1	42,567	.59	15,800
Portsmouth	.63	22,759	1.96	87,821
Punxsutawney	....	....	...	....
Sandusky	1.2	70,530	2	140,000
Steubenville	....	....	.....	....
Urbana	1.41	79,145	.	....
Westerville	....	....	3/5	16,000
Youngstown	2.39	13,770	.....	....
Indiana—				
Bedford	....	....	.....	....
Evansville	7	232,127	.....	....
Fort Wayne	11.91	417,712	8	285,000
Frankfort	1.40	47,456	1.60	70,000
Goshen	....	78,610	1½	75,000
Huntington	.4	18,250	.....	.....
La Porte	1.6	79,519	.73	16,500
Logansport	2.56	104,734	1	84,000
Portland	3.66	....	1¾	....
Shelbyville	....	....	.....	....
South Bend	2.80	85,483	6½	278,688
Terre Haute	....	....	1½	100,000
Illinois—				
Decatur	5	239,885	.....	....
Granite City	....	31,000	2	100,000
Jacksonville	....	....	.....	....
Kankakee	....	....	.....	....
Kewanee	....	....	3½	107,000
Mattoon	2⅓	76,000	2	70,000
Oak Park	12.64	497,831	9.54	391,913
Ottawa	1	33,000	4	200,000
Pana	....	....	.....	....
Peoria	3.55	114,809	.....	....
Pontiac	½	17,860	2.65	....
Rockford	6.95	180,370	4	100,000
Waukegan	....	....	.....	....
Michigan—				
Ann Arbor	3/5	28,000	½	22,000
Battle Creek	4	96,349	.....	....
Bay City	....	....	.....	....
Flint	8.39	....	9.5	....
Grand Rapids	8.369	211,000	.....	....
Houghton	....	....	.....	....
Ionia	¼	8,000	¼	8,000
Marquette	¼	4,661	1	15,000
Negaunee	....	....	.....	....
Niles	....	....	.....	....
St. Joseph	....	....	.....	....
Wisconsin—				
Appleton	3	35,000	1.04	40,000
Antigo	....	....	.....	....
Eau Claire	1.06	28,730	1.43	67,520
Fond du Lac	1.74	47,136	2.5	60,000
Janesville	....	16,916	.....	80,000
La Crosse	....	7,759	.....	101,000
Marinette	¾	16,138	¾	17,000
Merrill	1/5	1,300	1½	24,000
Oshkosh	38/100	20,534	4½	150,000
Sheboygan	3.10	87,474	.....	....
Stevens Point	1½	38,000	.....	....
Superior	2.50	49,000	2	40,000
Watertown	....	....	.....	....
Waukesha	.70	16,447	.....	4,500
West Allis	3	92,500	?	?
West North Central Division:				
Minnesota—				
Duluth	8.2	407,544	.....	....
Mankato	1¼	12,326	.....	....
New Ulm	....	....	.....	....
Red Wing	....	....	.....	....
Rochester	2 63/100	88,810	.....	....
St. Paul	13.25	480,100	17	615,000
Iowa—				
Cedar Falls	....	....	2½	85,000
Centerville	....	....	.....	....
Charles City	....	....	.....	....
Dubuque	3	....	.....	....
Keokuk	1.6	56,206	2	90,000
Marshalltown	3½	80,202	4½	90,000
Mason City	10	331,918	5	150,000
Muscatine	3.5	79,951	.....	....
Sioux City	23	485,000	8	150,000
Missouri—				
Cape Girardeau	....	....	.....	....
Idependence	98/100+	20,540	3	75,000
Joplin	5	128,880	8	?
Moberly	....	....	½	17,000
Sedalia	....	29,000	?	?
Springfield	4—	57,547	5	75,000
Kansas—				
Atchison	.75	18,000	1	25,000
Independence	....	....	?	....
Manhattan	2.6	59,821	.....	....
Topeka	7.30	247,000	5.2	200,000
Wichita	3.1	104,420	.....	....
North Dakota—				
Devils Lake	....	....	.....	....
Grand Forks	.53	26,300	.7	25,000
Minot	3	....	.....	....
South Dakota—				
Lead	....	5,221	.....	1,050
Sioux Falls	7	295,133	2¼	60,000
Nebraska—				
Fremont	3¼	104,278	.....	....
Norfolk	6	200,000	.....	....
York	....	55,488	.....	....
South Atlantic Division:				
Virginia—				
Danville	....	....	.....	....
Newport News	....	....	.....	....
West Virginia—				
Clarksburg	½	28,000	½	30,000
Huntington	9.81	278,889	6	180,000
Martinsburg	....	....	8	300,000
Morgantown	5	125,000	4	120,000
Moundsville	....	6,735	.....	....
Parkersburg	2.17	74,000	.....	105,000
North Carolina—				
Charlotte	½	13,280	2	50,000
Concord	7	....	3/5	....
Durham	¾	23,000	.....	....
Gastonia	5	140,000	2½	70,000
Greensboro	2.07	....	.80	14,000
Raleigh	2 5/10	69,437	2	50,000
Wilmington	....	....	1	20,000
South Carolina—				
Charleston	....	....	.....	....
Georgia—				
Americus	....	27,500	.....	13,750
Macon	....	....	.....	....
Savannah	2.37	85,816	2.37	85,816
Florida—				
St. Augustine	.14	....	.....	....
East South Central Division:				
Kentucky—				
Bowling Green	....	....	.....	....
Frankfort	....	....	.....	....
Louisville	....	414,837	.....	450,000
Middlesboro	....	....	.....	15,290
Paducah	....	....	.....	64,000
Tennessee—				
Chattanooga	4.99	183,600	2	88,000
Clarksville	....	....	.....	....
Jackson	1.43	38,025	.96	35,637
Memphis	.89 100	28,899	.....	....
Alabama—				
Gadsden	....	....	.....	....
Montgomery	....	....	.....	....
Mississippi—				
Vicksburg	2.5	101,817	.....	....
West South Central Division:				
Arkansas—				
Argenta	....	....	3.3	65,000
Hot Springs	....	....	10	200,000
Louisiana—				
Lake Charles	....	10,800	5	94,000
Texas—				
Austin	2.772	137,200	4	160,000
Cleburne	....	....	1.5	....
Dallas	9.5	455,805	40	2,000,000
Greenville	....	750	.....	....
Hillsboro	1.4	34,300	1	27,000
Longview	½	500	.....	....
Mountain Division:				
Montana—				
Anaconda	2.9	124,592	.....	110,000
Bozeman	....	....	1	....
Butte	1.23	58,020	1.5	72,511
Great Falls	1.531	54,391	.....	....
Helena	....	10,200	.....	45,000
Missoula	....	....	.....	....
Colorado—				
Colorado Springs	....	....	.....	....
Denver	7.8	....	3.5	....
Pueblo	....	....	.....	....
Trinidad	....	....	.....	....
Idaho—				
Boise	1.91	106,374	1.50	85,000
Coeur d'Alene	....	....	.....	....
Wyoming—				
Cheyenne	....	....	.....	....
Boro of W. Wyoming	....	....	7/10	40,000
Utah—				
Salt Lake City	9.152	469,883	10	500,000
Pacific Coast Division:				
California—				
Long Beach	2.41	54,695	7	250,000
Los Angeles	....	....	.....	....
Oakland	11.8	341,000	.....	....
Pomona	,08	1,389	.....	200,000
Riverside	2⅓	40,775	1	....
San Diego	1.1	20,688	.....	....
Santa Ana	4.32	48,189	.....	....
Santa Barbara	1	33,500	5	200,000
Santa Rosa	....	....	¾	32,000
Vallejo	1.7	53,600	3.5	135,000
Oregon—				
Ashland	....	....	.....	....
Eugene	....	....	.....	....
Medford	....	....	.....	....
Salem	....	....	2.86	60,000
Washington—				
Aberdeen	1.22	42,193	.75	28,000
Everett	1	....	.....	....
Tacoma	.382	8,771	5.70	156,694

TABLE III.—LENGTH OF WORKING DAY AND PREVAILING WAGES OF LABOR IN 1916 FOR PAVING WORK.

	Working day, hours.	Common labor, per day.	Paver, per day.	Team with driver, per day.
New England Division:				
Maine—				
Biddeford	9	2.25	6.00	5.00
Portland	9	[1]2.25	3.50	6.00
New Hampshire—				
Laconia	9	2.25	....	4.50
Keene	..	....	....	....
Vermont				
Bennington	9	2.00	....	5.00
Burlington	..	....	....	....
Montpelier	9	2.00	5.00	4.50
Massachusetts—				
Adams	8	$2.00	$3.50	$5.00
Arlington	8	2.50	5.00	[2]5.50
Brookline	8	2.75	....	....
Cambridge	8	2.50	4.00	6.00
Everett	..	....	....	....
Greenfield	8	2.50	....	4.80
Haverhill	8	2.75	3.25	5.40
Lawrence	8	2.50	....	5.00
Lowell	8	2.25	4.25	5.50
Lynn	[3]52	2.50	2.90	5.25
Malden	8	2.50	....	6.00
Marlboro	8	2.50	3.50	5.25
Newton	8	2.50	....	....
Peabody	8	2.50	....	6.00
Revere	8	2.50	5.00	6.00
Somerville	8	[4]2.50	....	....
Springfield	8	*.32	*[5].35	*.70
Watertown	8	2.73	....	6.00
Westfield	8	2.25	....	5.50
Connecticut—				
Ansonia	8	2.50	4.00	*.70
Bridgeport	9	2.75	....	7.00
Derby	..	....	....	....
Hartford	..	....	....	....
Manchester	9	2.50	3.50	6.00
New Haven	10	[6]3.50	....	7.50
Stamford	9	2.75	....	5.50
Willimantic	..	....	....	....
Rhode Island—				
Providence	9	2.00	3.00	[2]5.00
Woonsocket	9	[7]3.00	*.62½	6.00

*Per hour. [1]$3 on contract work. [2]Double team. [3]Per week. [4]$2.25 to $2.50. [5]34-35 ct. [6]$2.50-$3.50. [7]$2.50-$3.00.

	Working day, hours.	Common labor, per day.	Paver, per day.	Team with driver, per day.
Middle Atlantic Division:				
New York—				
Albany	8	2.24	5.00	6.00
Batavia	8	2.00	*.70	5.50
Corning	..	....	....	....
Elmira	8	2.25	4.00	5.00
Fulton	8	[1]2.50	....	4.50
Gloversville	8	2.40	3.00	5.00
Hudson	..	....	....	....
Johnstown	8	2.50	3.50	6.00
Little Falls	8	2.40	5.50	4.80
Lockport	8	*.30	....	*.60
Middletown	8	2.00	2.50	4.50
Newburgh	8	....	....	....
Norwich	8	2.25	....	5.00
Ogdensburg	8	2.00	....	4.00
Olean	8	2.40	4.80	5.00
Oneida	8	2.50	....	5.50
Oneonta	8	2.00	....	5.00
Oswego	8	2.50	3.50	[2]5.00
Portchester	..	....	....	....
Port Jervis	9	2.25	....	5.00
New Jersey—				
Bayonne	9	2.50	5.00	6.50
Bloomfield	8	2.65	....	6.50
Boro North Blumfield	..	....	....	....
Burlington	..	....	....	....
Hackensack	..	....	....	....
Harrison	8	2.50	....	6.00
Millville	..	....	....	....
New Brunswick	10	3.00	....	6.00
Passaic	8	2.50	3.50	6.00
Phillipsburg	..	....	....	....
Plainfield	8	2.50	....	6.00
Ridgewood	8	2.50	5.00	5.00
Westfield	9	2.75	...	6.00
Pennsylvania—				
Altoona	10	2.25	....	5.00
Bradford	9	2.50	4.00	6.50
Carbondale	9	*[3].30	5.00	*.62½
Chambersburg	10	*.17½	....	*.40
Easton	..	....	....	....
Erie	10	[4]*.35	*.40	*.70
Farrell	9	2.75	3.50	6.00
Franklin	..	....	....	....
Greensburg	9	2.50	....	6.00
Greenville	..	....	....	....
Harrisburg	..	....	....	....
Jeannette	9	2.50	....	6.00
Lancaster	..	....	....	....
Lansford	..	....	....	....
Lock Haven	..	....	....	....
McKees Rocks	10	2.50	4.00	6.00
Monongahela City	9	[5]2.50	3.50	6.00
Boro of Juniata	8	*.25	*.30	5.00
Boro New Brighton	9	1.75	....	5.00
New Castle	9	2.25	3.50	6.00
Norristown	10	[5]2.50	[6]5.50	[7]6.00
Northampton	10	2.00	....	4.50
Oil City	9	2.50	3.00	6.00
Pittstown	9	2.25	3.50	5.00
Scranton	10	*.25	*.35	*.56¾
Shamokin	9	1.85	...	5.00
South Bethlehem	10	2.50	...	7.00
Wilkes-Barre	9	[8]2.25	...	5.00
Williamsport	10	2.25	3.00	5.00
York	10	2.00	....	*.45
Maryland—				
Baltimore	8	2.00	4.50	5.00
Frederick	10	1.50	....	4.00

*Per hour. [1]$2.00-2.50. [2]$4.00-5.00. [3]*25-30 ct. [4]*30-35 ct. [5]$2.00-2.50. [6]$4.50-5.50. [7]Cart-$4.00. [8]$2.00-2.25.

TABLE III. WORKING DAY AND WAGES (Continued).

	Working day, hours.	Common labor, per day.	Paver, per day.	Team with driver, per day.
East North Central Division:				
Ohio—				
Alliance	8	2.50	5.00	5.00
Bellefontaine	10	2.50	...	5.00
Bellaire	..	....	....	....
Cincinnati	8	2.25	5.60	6.00
Columbus	8	2.50	3.50	5.00
Conneaut	8	2.25	...	5.00
Dayton	..	2.50	3.50	6.25
Delaware	10	2.25	3.00	5.00
East Liverpool	9	2.25	....	6.00
Elyria	8	[1]3.00	....	6.00
Fostoria	10	*.25	*.50	*.50
Ironton	8	1.90	....	4.00
Lancaster	8	2.50	....	5.00
Lanesville	8	2.00	3.00	5.00
Lima	10	2.75	4.75	5.00
Mansfield	8	2.40	3.50	6.00
Marietta	8	2.00	2.50	5.00
Massillon	8	3.00	4.00	6.00
Middletown	8	2.25	....	[2]6.00
Newark	8	*.25	....	4.50
Painesville	9	2.37	5.40	6.00
Portsmouth	8	1.75	2.25	4.00
Punxsutawney	..	....	....	....
Sandusky	9	*.30	*.30	5.00
Steubenville	8	2.40	3.25	5.50
Urbana	10	2.50	4.50	6.00
Westerville	..	....	....	....
Youngstown	9	2.75	3.50	6.00
Indiana—				
Bedford	..	....	....	....
Evansville	10	2.00	3.50	4.00
Fort Wayne	10	*.27½	*.35	*.65
Frankfort	10	2.50	3.00	4.50
Goshen	10	2.25	4.00	5.00
Huntington	10	[3]*.30	*.65	5.00
La Porte	10	2.50	4.00	5.00
Logansport	10	2.50	5.00	4.50
Portland	10	2.00	....	4.00
Shelbyville	..	....	....	....
South Bend	10	*.30	*.60	6.00
Terre Haute	..	2.00	....	4.00
Illinois—				
Belleville	8	*.33	....	*.60
Chicago Heights	8	*.30	*.60	[4]7.00
Decatur	9	2.25	2.70	5.40
Granite City	9	2.70	....	6.00
Jacksonville	9	[5]3.00	....	5.00
Kankakee	..	....	....	....
Kewanee	..	....	....	....
Mattoon	10	2.25	3.00	4.50
Oak Park	8	3.00	5.85	7.00
Ottawa	9	2.25	3.00	4.50
Pana	..	....	....	....
Peoria	9	2.25	4.00	6.00
Pontiac	9	[6]2.75	....	5.00
Rockford	9	2.70	4.50	6.00
Waukegan	..	....	....	....
Michigan—				
Ann Arbor	9	3.00	6.00	6.00
Battle Creek	10	2.50	4.00	5.00
Bay City	10	2.50	4.00	4.50
Flint	10	.30	.45	6.50
Grand Rapids	8	2.40	4.00	5.00
Houghton	..	....	....	....
Ionia	10	2.50	5.00	5.00
Marquette	9	2.50	...	6.00
Negaunee	9	2.25	....	5.50
Niles	..	....	....	....
St. Joseph	9	2.50	5.00	5.00
Wisconsin—				
Appleton	10	2.50	3.50	5.00
Antigo	10	2.25	....	4.50
Eau Claire	10	2.25	....	4.50
Fond du Lac	10	2.75	....	5.00
Janesville	9	2.75	...	5.00
La Crosse	9	2.00	2.50	5.00
Marinette	10	2.25	....	4.50
Merrill	10	1.75	3.00	4.00
Oshkosh	10	2.75	....	4.50
Sheboygan	10	2.25	....	5.00
Stevens Point	10	2.50	3.50	5.00
Superior	10	3.00	4.00	6.00
Watertown	10	2.00	....	4.50
Waukesha	..	....	....	....
West Allis	10	2.50	....	5.00

*Per hour. [1]$2.50-3.00. [2]$5.00-6.00. [3]25-30 ct. [4]For 10 hours. [5]$2.50-3.00. [6]$2.25-2.75.

	Working day, hours.	Common labor, per day.	Paver, per day.	Team with driver, per day.
West North Central Division:				
Minnesota—				
Duluth	10	2.75	..	6.00
Mankato	10	2.50	3.50	5.00
New Ulm	10	2.25	3.50	4.50
Red Wing	..	....	....	....
Rochester	10	2.50	5.00	5.00
St. Paul	10	2.50	3.50	6.00
Iowa—				
Cedar Falls	..	....	....	....
Centerville	..	....	....	....
Charles City	..	....	....	....
Dubuque	10	2.25	4.00	6.00
Keokuk	10	2.25	4.50	5.00
Marshalltown	10	[1]3.00	5.00	5.00
Mason City	10	2.75	3.00	5.50
Muscatine	..	....	....	....
Sioux City	9	[2]2.75	5.00	5.00
Missouri—				
Cape Girardeau	10	2.50	3.50	4.50
Independence	10	2.25	....	4.00
Joplin	8	*.25	4.50	4.00
Moberly	10	2.00	3.00	4.00
Sedalia	..	....	....	....
Springfield	[1]10	1.75	2.00	4.00
Kansas—				
Atchison	8	2.00	2.50	4.00
Independence	8	2.00	3.00	3.50
Manhattan	8	2.00	...	4.00
Topeka	8	2.00	....	4.00
Wichita	8	[2]2.00	....	3.50
North Dakota—				
Devils Lake	..	....	....	....
Grand Forks	10	2.75	....	5.00
Minot	10	3.00	....	6.00
South Dakota—				
Lead	8	3.00	4.00	5.00
Sioux Falls	10	2.50	5.00	5.00
Nebraska—				
Fremont	10	2.25	4.00	4.50
Norfolk	10	2.50	4.00	5.00
York	10	2.25	[3]4.00	4.00

*Per hour. [1]8-10 hours. [2]$1.75-2.00. [3]$3.50-$4.00.

TABLE III.—WORKING DAY AND WAGES (Continued).

	Working day, hours.	Common labor, per day.	Paver, per day.	Team with driver, per day.
South Atlantic Division:				
Virginia—				
Danville	10	1.35	1.80	3.50
Newport News	..	....	....	....
West Virginia—				
Clarksburg	9	2.70	4.50	6.00
Huntington	10	2.50	3.00	5.00
Martinsburg	10	1.75	....	....
Moundsville	9	*.25	*.40	*.55
Morgantown	9	2.50	....	....
Parkersburg	10	2.00	4.00	5.00
North Carolina—				
Charlotte	10	1.25	....	4.00
Concord	10	1.50	5.00	4.50
Durham	10	1.50	....	4.00
Gastonia	10	1.25	....	4.00
Greensboro	10	1.50	3.00	3.50
Raleigh	10	1.75	2.50	4.50
Wilmington	10	1.75	2.25	5.00
South Carolina—				
Charleston	9	1.50	3.00	[1]2.50
Georgia—				
Americus	10	1.00	....	4.50
Macon	10	1.25	2.50	4.50
Savannah	9	1.75	3.00	5.00
Florida—				
St. Augustine	8	1.50	....	1.50

*Per hour. [1]Cart.

	Working day, hours.	Common labor, per day.	Paver, per day.	Team with driver, per day.
East South Central Division:				
Kentucky—				
Bowling Green	9	*.15	....	3.50
Frankfort	..	....	....	....
Louisville	10	1.75	[1]4.50	5.00
Middleboro	10	1.75	....	*.40
Paducah	10	[2]1.75	3.50	4.00
Tennessee—				
Chattanooga	10	1.50	3.50	4.00
Clarksville	10	1.50	....	3.50
Jackson	10	1.50	....	3.50
Memphis	8	1.75	3.00	5.00
Alabama—				
Gadsden	10	1.50	....	4.00
Montgomery	..	....	....	....
Mississippi	10	1.50	2.00	4.00

*Per hour. [1]$3.00-4.50. [2]$1.50-1.75.

	Working day, hours.	Common labor, per day.	Paver, per day.	Team with driver, per day.
West South Central Division:				
Arkansas—				
Argenta	..	....	....	....
Hot Springs	..	....	....	....
Louisiana—				
Lake Charles	10	1.75	2.50	5.00
Texas—				
Austin	8	1.75	....	3.50
Cleburne	8	1.75	...	3.50
Dallas	8	2.00	4.00	3.50
Greenville	..	2.00	....	4.00
Hillsboro	8	2.00	3.50	4.00
Longview	8	1.50	2.50	4.00

*Per hour.

	Working day, hours.	Common labor, per day.	Paver, per day.	Team with driver, per day.
Mountain Division:				
Montana—				
Anaconda	8	3.50	5.50	....
Bozeman	8	3.00	....	6.00
Butte	8	4.00	....	7.50
Great Falls	8	3.50	5.00	7.00
Helena	8	3.00	....	7.00
Missoula	8	3.00	...	6.00
Colorado—				
Colorado Springs	..	....	....	....
Denver	8	2.50	....	5.00
Pueblo	8	2.50	....	4.50
Trinidad	..	....	....	....
Idaho—				
Boise	8	2.50	....	5.00
Coeur d'Alene	..	....	....	....
Wyoming—				
Cheyenne	..	....	*.30	5.00
W. Wyoming Boro	9	2.25	3.00	5.00
Utah—				
Salt Lake City	8	2.25	3.30	5.00

*Per hour.

	Working day, hours.	Common labor, per day.	Paver, per day.	Team with driver, per day.
Pacific Coast Division:				
California—				
Long Beach	9	2.50	2.75	7.00
Los Angeles	9	2.50	[illegible]	7.50
Oakland	8-9	2.50	...	6.00
Pasadena	8	2.25	...	[illegible]
Riverside	8	2.25	...	4.40
San Diego	8	2.50	.	6.00
Santa Ana	9	2.25	3.50	[1]5.00
Santa Barbara	8	2.25	3.50	5.50
Santa Rosa	8	2,50	[illegible]	[illegible]
Vallejo	9	[illegible]	...	[illegible]
Oregon—				
Ashland	..	....	....	....
Eugene	..	....	....	....
Medford	..	....	....	....
Salem	8	2.40	...	4.50
Washington—				
Aberdeen	8	2.50	[illegible]	7.00
Everett	..	2.65		6.00
Tacoma	8	2.50	[illegible]	[illegible]

*Per hour. [1]$4.50-5.00.

TABLE IV.—AMOUNT, AVERAGE PRICE AND DETAILS OF CONCRETE PAVEMENT CONSTRUCTED IN 1916 IN VARIOUS CITIES.

	Square yards.	Type.	Total thickness, ins.	Av. price per sq. yd., incl. grad'g.	Guarantee, yrs.	Bottom course.	
						Thickness, ins.	Proportions.
New England Division:							
Massachusetts—							
Lynn	53,231	1-course	6	1.47½	.	.	.....
Malden	9,400	1-course	8	....	.	.	.....
Somerville	9,714	Bit-top	7½	1.36	.	5	1:3:6
Springfield	32,142	1-course	6	1.75	.	6	1:2.1:3.8
Connecticut—							
Manchester	9,685	1-course	7	1.27	.	7	1:2:4
Middle Atlantic Division:							
New York—							
Gloversville	12,380	1-course	6	1.55	0	6	1:2:3
Little Falls	564	1-course	7	*1.50	.	.	.....
New Jersey—							
Westfield	10,000	1-course	7	1.50	1	.	1:1¾:3
Pennsylvania—							
Juniata	8,811	2-course	7	1.64	5	.	1:2½:5
Northampton	4,782	1-course	7½	1.46	.	.	.....
Maryland—							
Baltimore	78,410	1-course	6	*1.15	5	6	1:2:4
Frederick	817	2-course	.	1.012	.	.	.....
East North Central Division:							
Ohio—							
Bellefontaine	4,200	1-course	6	*1.38	0	6	1:2:3
Cincinnati	2,900	Reinforc'd	7	1.47	1	.	.....
Dayton	[1]4,600	1-course	6	1.54	5	6	1:2:3
Delaware	1,400	1-course	8	*.93	5	.	.....
East Liverpool	6,116	1-course	[2]8	1.70	1	.	1:1½:3
Fostoria	2,638	....	6	*1.43	2	6	1:2:3
Ironton	1,531	1-course	7	1.78	5	7	1:1½:3
Lima	1,936	1-course	6	*1.35	.	6	1:3:6
Marietta	9,795	1-course	.	1.33	5	.	.....
Massillon	10,000	Bit-top	7	1.14	1	5	1:3:6
Middletown	45,230	1-course	7	1.30	5	.	1:2:3
Painesville	908	2-course	7½	*1.62	1	[3]4	1:2½:4
Sandusky	1,600	2-course	7	*1.50	5	4	1:2:4
Urbana	390	1-course	.	1.50	5	6	1:2:3
Zanesville	5,635	1-course	7	*1.35	3	7	1:1½:3
Indiana—							
Evansville	3,760	1-course	7	1.38	5	7	1:2:4
Evansville	5,170	Bit-top	7	1.40	5	7	1:2:4
Fort Wayne	14,214	2-course	7	*1.52	5	5	1:2:4
South Bend	3,422	1-course	7	*1.17	1	.	.....
Illinois—							
Belleville	66,000	2-course	9	1.62	.	[4]6½	1:2½:4
Granite City	13,500	2-course	7	*1.58	.	[5]5	1:2½:4
Oak Park	2,841	2-course	7	*1.64	.	.	1:2:3
Oak Park	1,848	1-course	6	*1.44	5	6	1:2:3
Peoria	9,453	1-course	6	*1.06	.	6	1:2:3
Rockford	.....	1-course	6	*1.10	1	.	.....
Rockford	.....	Bit-top	8	*.72	1	.	.....
Michigan—							
Bay City	5,798	1-course	5	*.90	5	5	1:3:5
Grand Rapids	54,003	1-course	7	*1.30	5	.	.....
Wisconsin—							
Eau Claire	8,388	1-course	7	1.45	.	.	.....
Eau Claire	1,630	2-course	7	1.65	.	.	.....
Fond du Lac	1,809	2-course	6½	1.60	5	.	1:2½:5
Marinette	11,053	2-course	7	*1.24	1	.	1:2½:5
Oshkosh	1,872	1-course	.	1.40	5	.	.....
Sheboygan	53,033	2-course[1]	7½	1.43	0	.	1:2:5
Stevens Point	6,269	2-course	7	*1.42	5	5	1:3:5
Superior	[6]27,326	....	7	*1.35	5	.	.....
West Allis	[6]30,469	1-course	[7]7	*1.37	.	.	.....
West North Central Division:							
Minnesota—							
Duluth	43,832	1-course	8	*1.74	5	.	1:1½:3
Mankato	9,339	1-course	6	1.32	.	.	....
Rochester	14,788	1-course	7	1.41	5	.	1:2:3
Rochester	16,285	Bit-top	7½	1.52	1	5	1:3:5
St. Paul	1,786	1-course	7	1.66	.	.	.....
Iowa—							
Dubuque	[6]5,000	....	7	1.50	5	.	1:2:4
Dubuque	10,000	Bit-top	6	1.60	5	5	1:2:4
Keokuk	33,064	1-course	7	1.32	2	.	.....
Marshalltown	43,543	1-course	6	1.27½	1	.	1:2:3
Mason City	33,211	2-course[1]	7	1.63	5	[8]5	1:2½:4
Sioux City	286,000	1-course	[9]6	[9]1.25	.	.	1:2½:4½
Missouri—							
Cape Girardeau	18,800	1-course	6	*1.00	0	.	1:1½:3
Joplin	24,934	2-course[1]	6	1.32	0	4½	1:4½
Joplin	1,554	1-course	5	.86	0	.	1:6
Sedalia	7,462	1-course	6	1.09	.	.	1:2:3
Springfield	3,752	1-course	5	1.28	.	5	1:2:4
North Dakota—							
Grand Forks	9,739	....	6½	*1.59	2	.	.....
South Dakota—							
Lead	1,597	1-course[1]	6	*2.17	.	6	1:2:4
Sioux Falls	9,612	1-course	6	*1.45	2	6	1:2:4
Nebraska—							
Fremont	45,422	1-course	6	1.37	3	.	1:2½:4
Norfolk	12,000	1-course	6	1.38	1	.	.....
Norfolk	35,000	1-course	[10]5	1.24	1	.	.....
Kansas—							
Independence	467	2-course	6	*1.20	.	4	1:3:5
Wichita	7,933	1-course	6	*1.09	2	6	1:2:4
Wichita	663	2-course	6	*1.09	2	4	1:3:5
Wichita	6,777	Bit-top	6⅛	*1.29	2	6	1:3:5
South Atlantic Division:							
West Virginia—							
Parkersburg	2,100	1-course	6½	*1.19	.	6½	1:1½:3
North Carolina—							
Charlotte	8,800	1-course	6	1.51	3	.	1:2:4
Greensboro	[11]3,059	1-course	5	1.04	.	5	1:2:4
Georgia—							
Americus	22,000	1-course	6	1.00	.	6	1:2:3
Macon	137,125	1-course	7	1.17	.	.	1:2:3
Savannah	31,503	1-course	6¼	1.38	.	.	.....
East South Central Division:							
Kentucky—							
Louisville	1,139	....	.	*1.20	5	6	1:1½:3
Tennessee—							
Memphis	1,340		6	....	0	.	.....
West South Central Division:							
Texas—							
Dallas	10,359	Bit-top	6	1.75	5	.	1:5½
Greenville	500	1-course	.	....	.	.	.....
Mountain Division:							
Montana—							
Butte	1,859	1-course	6	1.75	5	6	1:2:4
Great Falls	7,796	1-course	6	....	2	6	1:2:4
Helena	2,500	1-course[1]	7	*1.65	.	.	1:1½:3
Colorado—							
Denver	12,000	2-course	6	1.35	5	.	1:3:5
Utah—							
Salt Lake City	36,508	1-course	5	*1.26	5	.	.....
Pacific Coast Division:							
California—							
Los Angeles	1,195	....	4	.93	.	.	.....
Los Angeles	31,300	....	5	1.08	.	.	.....
Los Angeles	4,035	....	6	1.17	.	.	.....
Los Angeles	3,353	Bit-top	5	1.08	.	.	.....
Riverside	36,017	Bit-top	4¾	.91½	.	4	1:2½:5
San Diego	12,423	1-course	4	.88	0	4	1:2:4
San Diego	5,640	Bit-top	5½	1.15	0	4	1:3:6
Vallejo	3,550	1-course	5	*1.08	0	5	1:2:4
Vallejo	2,830	1-course	6	*1.26	0	6	1:2:4
Washington—							
Aberdeen	512	2-course	7	*1.50	.	5	.....
Everett	15,213	1-course	6	*1.25	.	6	1:2:3
Tacoma	1,763	2-course	.	1.81	.	.	1:3:6

---

*Does not include grading.

[1] Reinforced. [2] 9-in. center; 6-in. sides. [3] 5-in. center; 4-in. sides. Upper course 1:1½:2½. [4] Top 1:1:2. [5] Granite top 1:1½:2½. [6] 1 and 2-course type. [7] 2-course was 6½-in. thick and cost $1.51. [8] Granite top, 1:1:1½. [9] 6-in. and 8-in.; price from $1.25 to $1.63. [10] 5-in.-7-in. [11] Placed by city convicts using city teams, roller and mixer. [12] 1-course, reinforced, 5 in. at curb, 7 in. at center; cost $1.25 per sq. yd. [13] Vibrolithic; 1⅜-in. bit. top. [14] 5-in. to 7-in.. [15] Alleys.

TABLE V. AMOUNT, AVERAGE PRICE AND DETAILS OF BITULITHIC PAVEMENT CONSTRUCTED IN 1916 IN VARIOUS CITIES.

	Square yards.	Av. price per sq. yd., including base and grading.	Guarantee, years.	Price per cu. yd. for grading if paid separately.	Total thickness pavement, ins.	Concrete base.	
						Thickness, ins.	Proportions.
New England Division:							
Massachusetts—							
Cambridge	10,310	$2.75	5	....	7	5	1:2½:5
Haverhill	728	2.38	5	....	6	4	1:2:5
Haverhill	[1]19,753	1.65	..	....	..	..	......
Rhode Island—							
Providence	20,552	2.10	5	....	8	6	1:3:6
Woonsocket	7,890	2.35	5	....	..	6	1:3:6
Middle Atlantic Division:							
New York—							
Elmira	10,643	2.25	5	....	7	5	1:2½:5
Little Falls	9,265	[1]2.35	5	$0.85	7	5	1:2½:5
Oneida	4,874	2.45	5	....	7	5	1:2½:5
New Jersey—							
Bloomfield	5,100	2.33	5	....	8	6	1:3:5
Harrison	18,512	2.20	5	....	8	6	1:3:6
East North Central Division:							
Ohio—							
Cincinnati	1,088	2.40	5	....	..	..	1:3:6
Youngstown	15,880	*2.00	..	.40	[2]7	5	1:3:6
Michigan—							
Battle Creek	63,943	1.28	..	....	7	5	1:6
Bay City	19,116	*1.58	5	.50	7	5	1:3:5
Grand Rapids	14,110	*1.65	5	.40	7	5	1:3½:7
West Central Division:							
Iowa—							
Muscatine	25,615	1.83	5	....	7	5	1:6
Missouri—							
Joplin	15,411	1.85	0	....	7	5	1:6
North Dakota—							
Minot	24,634	*2.53	5	.60	7	5	1:6
South Dakota—							
Sioux Falls	42,734	*2.10	5	.60	[2]8	6	1:2½:5
South Atlantic Division:							
North Carolina—							
Greensboro	8,516	1.50	..	....	6	4	1:3:6
Greensboro	[3]11,709	.94	..	....	2	..	....
Raleigh	..	[4]1.70	..	....	6	4	1:3:6
West South Central Division:							
Arkansas—							
Hot Springs	4,000	....	5	.55	7	5	1:2:5
Texas—							
Austin	60,143	*2.00	..	.35	7	5	1:5
Dallas	[1]73,000	2.30	5	....	7	5	1:8
Mountain Division:							
Montana—							
Bozeman	[6]20,000	*1.97	5	.70	6	[5]..	....
Butte	22,586	2.55	5	....	6	4	1:3:5
Great Falls	18,830	....	5	....	6	4	1:3:5
Missoula	18,000	*2.09	5	.87	6	4	1:3:6
Colorado—							
Denver	25,000	2.00	5	....	8	5	1:3:5
Pueblo	40,400	*2.37	5	.35	7	5	1:2½:5
Idaho—							
Boise	46,628	*1.64	5	.70	5	..	....
Utah—							
Salt Lake City	40,452	*1.86	5	.60	6	..	....
Pacific Coast Division:							
California—							
Los Angeles	52,197	1.40	..	....	6	4	....
Los Angeles	99,239	1.48	..	....	7	5	....

*Does not include grading. [1] Bitulithic surfacing on old concrete base. [2] 7-in. and 8-in. [3] 2-in. surface on old macadam. [4] Warrenite: 65 ct. for 4-in. base, $1.05 for 2-in. top. [5] On rock base. [6] Gravel bitulithic.

TABLE VI.—AMOUNT, AVERAGE PRICE AND DETAILS OF BITUMINOUS CONCRETE LAID IN 1916 IN VARIOUS CITIES.

					Concrete base.	
	Square yards.	Average price per sq. yd., including base and grading.	Guarantee, yrs.	Total thickness pavement, ins.	Thickness, ins.	Proportions.
New England Division:						
Maine—						
Portland	[1]6,028	$1.67	5	6	[2]5	1:2
Massachusetts—						
Marlboro	44,193	*1.12	..	[3]5	..	.....
Revere	1,245	1.50	..	..	..	.....
Somerville	[4]16,863	.95	..	2½	..	.....
Somerville	[1]10,778	1.52	..	6	5	1:3:6
Springfield	[5]52,505	1.07	..	2	..	....
Connecticut—						
Bridgeport	[1]290,714	[7]1.69	5	2	..	.....
Stamford	[1]5,308	1.71	5	7	5	1:3:5
Middle Atlantic Division:						
New York—						
Albany	13,393	*1.71	5	8½	6	1:3:6
Oswego	1,425	*1.65	5	8	5	1:3:6
New Jersey—						
Bayonne	[9]5,385	1.15	10	8	..	.....
Hackensack	7,916	*1.13	1	[8]7	..	.....
New Brunswick	[9]89,319	2.70	5	7	5	1:3:6
Pennsylvania—						
Harrisburg	10,361	1.33	5	6	4	1:3:5
Northampton	[10]4,372	1.55	..	7½	5	1:3:5
South Bethlehem	[10]6,156	1.59	.	7	4	1:2½:5
East North Central Division:						
Ohio—						
Lima	9,852	*1.72	..	8	6	1:3:6
Newark	13,243	1.55	5	6	4	1:6
Indiana—						
Fort Wayne	72,790	*1.60	5	8	6	1:3:6
Frankfort	4,565	*1.70	5	7	5	1:2½:5
South Bend	37,444	*1.48	5	7	5	1:3:6
Illinois—						
Chicago Heights	57,000	1.00	5	8	6	1:3:6
Kankakee	22,000	....	5	7	5	1:3:6
Oak Park	[11]40,359	1.58	5	6	4	1:3:6
Oak Park	138,707	*1.47	5	8	6	1:3:6
Oak Park	[12]1,125	1.05	5	4	..	.....
Peoria	6,044	*1.18	5	6½	..	.....
Wisconsin—						
Fond du Lac	22,375	1.53	5	7	5	1:3:5
Oshkosh	3,933	1.63	5	..	..	.....
West North Central Division:						
Minnesota—						
St. Paul	95,350	1.54	..	7	5	1:3:5
Iowa—						
Muscatine	3,654	1.51	5	7	5	1:6
Missouri—						
Springfield	7,073	1.43	5	6	4	1:3:7
Springfield	12,900	1.28	5	6	..	.....
South Dakota—						
Sioux Falls	84,243	*1.54	5	8	6	1:2½:5
Nebraska—						
Norfolk	65,000	1.51	5	7	5	1:5½
Kansas—						
Manhattan	41,000	*1.22	5	7	5	1:3:5
South Atlantic Division:						
North Carolina—						
Raleigh	....	1.52	..	6	4	1:3:6
East South Central Division:						
Tennessee—						
Chattanooga	32,520	*1.40	5	7	5	1:3:6
West South Central Division:						
Texas—						
Hillsboro	13,000	*1.60	5	7	5	1:3:5
Mountain Division:						
Montana—						
Anaconda	[13]75,510	*1.65	5	5	..	.....
Colorado—						
Denver	25,000	1.80	5	..	..	.....
Utah—						
Salt Lake City	13,735	*1.62	5	6	..	.....
Pacific Coast Division:						
California—						
Long Beach	16,081	1.17	..	4	..	.....
Long Beach	4,420	1.42	..	5½	..	.....
Los Angeles	7,504	.85	..	4½	..	.....
Los Angeles	23,803	.91	..	7½	4	.....
Los Angeles	22,838	1.25	..	4½	[15]3	.....
Los Angeles	2,352	1.45	..	6½	5	.....
Santa Rosa	17,000	1.20	..	5	..	.....
Vallejo	40,000	*1.08	..	5	4	1:2½:5
Oregon—						
Salem	15,542	.97½	..	7	..	.....
Washington—						
Aberdeen	1,458	*1.60	..	8	6	1:6

*Does not include grading. [1]Hassam Bi-co-mac. [2]Crushed rock base filled with grout. [3]Includes 4-in. stone base. [4]Laid on old concrete. [5]On old macadam base. [6]Warrenite on old macadam. [7]2-in. wearing surface cost $1.20 per sq. yd.; remaining cost was for shaping up old macadam and some grading. [8]Includes 5-in. macadam. [9]Warrenite. [10]Amiesite. [11]Resurfacing over old macadam; price includes preparation of old macadam. [12]Price includes preparation of old macadam and 2 in. of macadam. [13]Includes 4-in. waterbound base. [14]7 in. and 8 in.; concrete 5 in. and 6 in. [15]3-in. bituminous base, 2-in. top. [16]Bituminous concrete.

TABLE VII.—AMOUNT, AVERAGE PRICE AND DETAILS OF WOOD BLOCK PAVEMENT LAID IN 1916 IN VARIOUS CITIES.

						Concrete base.	
	Square yards.	Kind of filler.	Av. price per sq. yd. including base and grading.	Guarantee, yrs.	Total thickness pavement, ins.	Thickness, ins.	Proportions.
New England Division:							
Massachusetts—							
Brookline	1,307	Sand	3.23	5	9	5	1:3:6
Cambridge	970	Grout	4.20	.	9	5	1:2½:5
Marlboro	4,550	....	*3.09	.	..	4	.....
Springfield	842	Pitch[2]	3.11	.	8½	5	1:3:6
Connecticut—							
New Haven	[3]47,098	Sand	[4]2.44	5	..	.	.....
Middle Atlantic Division:							
New York—							
Middletown	6,200	....	2.85	.	9	5	1:5
Maryland—							
Baltimore	[5].....	Asphalt[6]	*3.80	5	11	6	1:3:6
East North Central Division:							
Ohio—							
Cincinnati	34,350	Pitch[7]	3.12	2	..	.	1:3:6
Dayton	29,227	Bitum	2.91	5	10	6	1:3:6
Indiana—							
Fort Wayne	7,492	Sand	*2.00	5	9½	5	1:3:6
Wisconsin—							
West Allis	15,800	....	*2.35	5	9½	6	1:3:6
West North Central Division:							
Minnesota—							
Rochester	19,293	Pitch	2.24	5	9	5	1:3:5
St. Paul	110,304	Pitch	2.74	.	9½	5	1:3:5
Iowa—							
Dubuque	50,000	Asphalt	2.50	1	9	5	1:3:5
Missouri—							
Joplin	1,153	Asphalt	2.14	0	..	[8]	1:6
North Dakota—							
Minot	25,028	Pitch	*2.89½	5	9½	5	1:
Minot	4,582	Pitch	2.98	5	9½	5	1:6
Minot	[9]2,984	Pitch	3.08	5	9½	5	1:6
East South Central Division:							
Kentucky—							
Louisville	1,028	Asphalt	*3.05	5	..	6	.....
Paducah	5,525	Asphalt	....	.	..	.	.....
Tennessee—							
Chattanooga	22,800	Asphalt	*2.50	5	10	6	1:3:6
Memphis	12,430	...	[10]1.65	5	..	.	.....
West South Central Division:							
Texas—							
Dallas	[11]4,882	Asphalt	3.45	5	11	6	1:8
Dallas	[12]30,887	Asphalt	3.10	5	10½	6	1:8
Pacific Coast Division:							
California—							
Los Angeles	2,730	Sand	3.15	.	10	'	.....

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*Does not include grading.

[1]Has on base. [2]Pitch cement, sand. [3]Repaving on old concrete base. [4]$2.44 to $2.64. [5]On sand-cement bed. [6]Asphalt and cement. [7]Pitch and Mastic. [8]Old base remodeled. [9]Alleys. [10]On old base. [11]4-in. x 8-in. block. [12]3½-in. x 4-in. x 8-in. block.

TABLE VIII.—AMOUNT, AVERAGE PRICE AND DETAILS OF ASPHALT PAVEMENT CONSTRUCTED IN 1916 IN VARIOUS CITIES.

							Concrete base.	
	Square yards.	Thickness of binder, ins.	Thickness of surface, ins.	Av. price per sq. yd., including base and grading.	Guarantee, years.	Price per cu. yd. for grading if paid separately.	Thickness, ins.	Proportions.
New England Division:								
Massachusetts—								
Revere	2,791	...	3	$1.50	.	....	.	....
Springfield	[1]4,459	1½	1½	1.73	.	....	.	....
Connecticut—								
Hartford	51,743	1½	1½	1.58	5	$0.60	6	1:3:6
New Haven	[2]98,868	...	...	.76	5	....	.	....
New Haven	5,460	1½	1½	1.84	5	....	6	1:3:6
Stamford	9,341	0	2	1.64	5	...	5	1:6
Rhode Island—								
Providence	28,009	1½	1½	[illegible]	[illegible]	....	6	1:3:6
Middle Atlantic Division:								
New York—								
Albany	40,125	1	2	*1.77	5	.35	6	1:3:6
Batavia	3,000	...	2	1.75	5	....	6	1:2½:5
New Jersey—								
Bayonne	46,480	1½	1½	1.80	10	...	5	1:3:6
Bayonne	[3]38,460	...	...	1.80	10	....	.	....
Passaic	19,990	1½	1½	*1.62	5	...	6	1:3:6
Pennsylvania—								
Erie	30,284	1½	1½	1.69	5	....	5	1:2½:7
Harrisburg	10,233	1	2	2.00	5	....	6	1:3:5
Scranton	13,840	1	2	1.83	[illegible]	....	6	1:3:6
Wilkes-Barre	38,914	1½	2	2.00	10	....	6	1:3:6
York	15,271	1	2	1.85	5	....	6	1:3:5
Maryland—								
Baltimore	398,873	1½	1½	*1.15	5	.85	[illegible]	1:3:6
East North Central Division:								
Ohio—								
Cincinnati	2,660	1½	1½	2.48	5	....	.	1:3:6
Columbus	115,964	1	2	*2.024	5	.70	6	1:3½:7
Conneaut	[illegible]	1	2	*1.40	5	.35	6	1:3:6
Elyria	[illegible]	1	2	*2.00	5	.50	6	1:3:5
Lima	25,106	1	2	[illegible]	[illegible]	.50	6	1:3:6
Newark	18,858	1	1½	[illegible]	5	....	.	....
Indiana—								
Evansville	108,486	1	2	1.80	5	.	5	1:3:6
Fort Wayne	45,112	1	1½	*1.70	5	.48	6	1:3:6
Goshen	24,046	1	1½	1.82	5	.40	5	1:3:5
La Porte	[illegible]	1	1½	1.78	5	...	6	1:3:6
Logansport	44,518	1	1½	1.95	5	..	[illegible]	1:3:5
Illinois—								
Kankakee	17,000	1½	1½	....	[illegible]	.60	5	[illegible]
Oak Park	[illegible]	1½	1½	*1.82	[illegible]	[illegible]	6	[illegible]
Michigan—								
Flint	101,000	1	1½	*1.35	.	.45	6	1:2:5
Grand Rapids	1,178	1½	1½	*1.90	5	.40	5	1:3½:7
West North Central Division:								
Minnesota—								
Duluth	21,567	1	2	*2.12	5	[illegible]	[illegible]	[illegible]

TABLE VIII.—AMOUNT, AVERAGE PRICE AND DETAILS OF ASPHALT PAVEMENT LAID IN 1916 (Continued).

	Square yards.	Thickness of binder, ins.	Thickness of surface, ins.	Av. price per sq. yd., including base and grading.	Guarantee, years.	Price per cu. yd. for grading if paid separately.	Concrete base. Thickness, ins.	Concrete base. Proportions.
Iowa—								
Dubuque	50,000	2	...	1.80	5	....	5	1:2:4
Mason City...	132,066	1	1½	1.68	5	....	5	1:3:6
Sioux City....	12,000	1	2	2.10	5	....	5	1:2½:4½
Kansas—								
Topeka	64,100	...	2	*1.35	5	.38	5	1:2½:5
South Atlantic Division:								
North Carolina—								
Concord	...	1	2	....	.	....	.	......
Durham	8,200	1½	1½	*1.72	5	.35	4	1:3:6
Gastonia	80,000	1½	1½	*[5]1.36	5	.30	4	1:3:6
Greensboro ..	6,415	1½	1½	1.62	5	....	4	1:3:6
South Carolina—								
Charleston ...	57,828	1½	1½	1.43	5	....	4	1:3:6
East South Central Division:								
Kentucky—								
Louisville	47,747	[6]1	2	*1.74	5	....	6	1:3:6
Tennessee—								
Chattanooga .	29,100	2	2	[1].96	5	....	.	....
Mississippi—								
Vicksburg ...	26,247	...	2	*1.75	5	.50	4	1:3:5
Mountain Division:								
Colorado—								
Denver	63,000	1½	2	1.85	5	....	5	1:3:5
Utah—								
Salt Lake City.	125,932	1½	1½	*1.80	5	.60	6	1:3.6
Pacific Coast Division:								
California—								
Long Beach..	8,297	1	1½	1.55	.	....	4	1:3.6
Long Beach..	6,878	1	1½	1.66	.	....	6	1:3:6
Los Angeles..	3,983	...	1	.81	.	....	[7]3	....
Los Angeles..	3,350	...	1½	.90	.	....	[7]3	....
Los Angeles..	[8]65,993	...	1½	.93	.	..	4	....
Los Angeles..	33,416	[9]1	1½	.95	.	....	4	....
Los Angeles..	11,181	[9]1	1½	...	.	....	5	....
Los Angeles..	[8]21,861	...	2	1.12	.	....	5	....
Los Angeles..	381,443	[9]1	2	1.17	.	....	5	....
Los Angeles..	14,707	[9]1	2	1.26	.	....	6	....
Oakland	52,678	2	1½	*1.50	0	....	6	1:3:6
San Diego....	2,077	1	2	1.55	0	....	5	1:3:5
Santa Ana....	12,374	...	1½	1.03½	.	....	4	1:3:6
Santa Barbara	16,000	...	[10]1½	1.40	.	....	4	1:3:6
Washington—								
Aberdeen	19,520	...	2	*1.53	.	...	6	1:6
Tacoma	1,888	1	1½	2.59	0	...	5	1:3:6

*Does not include grading. [1]On old concrete base. [2]On old macadam base. [3]5-in. and 6-in. [4]Resurfacing of old brick pavement. [5]$1.30 to $1.36. [7]1 and 1½-in. [7]3-in. bituminous concrete base. [8]Paint coat for binder. [9]Asphaltic concrete binder. [10]1½ in.-2 in. [11]4 in.-4½ in.

TABLE IX.—PREVAILING LOCAL PRICES IN 1916 FOR MATELIALS USED IN PAVEMENT CONSTRUCTION.

	Portland cement, per bbl.	Broken stone, per cu. yd.	Sand, per cu. yd.	Paving brick, per sq. yd.	Asphalt, per ton.	Creosoted wood block, per sq. yd.	Granite block, per sq. yd.	Gravel, per cu. yd.
New England Division:								
Maine—								
Biddeford	$2.50	$1.30	$1.00	...	....	....	....	....
Portland	2.10	*1.625	1.00	...	....	...	$1.41	....
New Hampshire								
Laconia	....	*1.43	1.00	.	....	....	....	....
Vermont—								
Bennington	1.75	2.00	1.00	....	....	...	....	[1]$2.00
Montpelier	....	*1.25	1.20	....	....	....	....	1.20
Massachusetts—								
Adams	1.80	1.25	1.25	$0.74	....	....	....	....
Cambridge	1.32	2.60	1.00	.	....	$2.05	....	1.00
Greenfield	2.20	1.10	1.25	....	....	....	....	....
Haverhill	1.91	*1.30	.75	....	‡$0.06¾	....	†.65	.75
Lawrence	**1.54	....	1.00	..	...	...	1.48½	1.25
Lowell	1.60	*1.25	.30	.	....	....	†.45	.30
Lynn	1.99	*1.00	.70	...	....	....	1.47	1.00
Malden	....	*1.50	1.00	.	....	....	....	1.00
Marlboro	**2.00	*1.40	1.25	.	.27	...	....	1.25
Peabody	1.85	.85		.	20.00	...	....	....
Revere	**1.79	*1.14	1.35	.	....	. .	1.70	...
Springfield	[2]2.55	[3]*1.05	[4].70	1.33	[5]16.50	1.73	†62.00	.15
Watertown	[6]2.12	[7]1.50	.		...	....	....	[8].91
Westfield	1.85	1.49	1.25	...	..	....	....	....
Connecticut—								
Ansonia ...		1.85	1.50		.	..	....	1.50
Bridgeport	1.86	1.56	1.50			...	...	1.50
Manchester	....	1.46	.25	.			...	.25
New Haven	2.25	1.35	1.00	†22.00	14.00	2.35	...	....
Stamford	2.20	1.10	...	...	....	....	....	....
Rhode Island—								
Providence	1.58	1.69	.	..	....	...	1.96	1.20
Woonsocket	[9]1.60	[7]*1.70	1.00	.	....	.	....	....
Middle Atlantic Division:								
New York—								
Albany	2.00	2.10	[7]1.60	[7]1.15	20.00	2.10	1.85	[7]1.40
Batavia	1.40	1.28	1.25	.90	20.00	...	....	1.25
Elmira	1.60	1.50	1.50	1.00	...	..	....	....
Fulton	1.90	1.00	1.20	2.50	...	....	....	2.00
Gloversville	[illegible]	1.00	.50	...		...	...	....
Johnstown	**1.87	2.00	1.25	..	.	.	1.80	1.25
Little Falls	1.40	[7]1.75	1.10	...	...	....	....	....
Lockport	.		..	...	....	....	....	1.25
Middleton			.50			[10]1.60	.	.70

TABLE X.—PREVAILING LOCAL PRICES IN 1916 FOR MATERIALS USED IN PAVEMENT CONSTRUCTION.

	Portland cement, per bbl.	Broken stone, per cu. yd.	Sand, per cu. yd.	Paving brick, per sq. yd.	Asphalt, per ton.	Creosoted wood block, per sq. yd	Granite block, per sq. yd.	Gravel, per cu. yd.
Norwich	1.87	*1.23	2.00	....	....	....	....	1.50
Ogdensburg	....	1.25	1.25	....	....	....	....	....
Olean	1.80	[11]1.80	1.50	.85	....	....	....	1.40
Oneida	2.00	1.60	1.25	....	....	....	....	....
Oneonta	1.95	1.65	1.00	....	....	....	....	....
Port Jervis	1.50	1.75	.75	....	....	....	....	.75
New Jersey—								
Bayonne	1.30	1.65	1.25	....	....	....	2.15	1.50
Harrison	1.78	1.50	1.00	....	....	....	....	....
New Brunswick..	....	2.00	1.25	1.10	....	....	....	....
Passaic	....	2.20	1.00	....	....	....	3.60	....
Plainfield	....	2.25	....	....	....	....	....	....
Ridgewood	1.80	2.25	1.00	.66	....	....	....	1.00
Westfield	1.54	1.50	1.50	....	....	....	....	1.50
Pennsylvania—								
Altoona	1.55	1.50	1.50	.95	....	1.68	....	....
Bradford	1.41	1.25	1.25	.68	25.00	....	....	1.00
Carbondale	1.95	1.43	[12]1.30	1.11	....	....	....	1.00
Chambersburg...	....	....	*.90	....	....	....	....	[13]1.21
Erie	2.08	*1.40	*.40	†19.00	20.36	....	....	1.50
Farrell	....	....	....	†17.50	....	....	....	...
Greensburg	....	....	....	.85	....	....	....	....
Jeanette	....	....	....	.84	....	....	....	....
Juniata	1.53	*1.17	*1.80	1.00	....	....	....	....
McKees Rocks ...	1.60	2.00	1.20	.70	....	....	1.50	1.00
Monongahela City	2.25	2.35	2.16	.84	....	....	....	2.16
New Brighton ...	1.50	....	1.35	....	....	....	....	....
New Castle	1.40	....	....	.73	....	....	....	[14].80
Norristown	1.65	[15]2.40	.90	.42	....	....	....	....
Northampton	1.65	1.35	1.50	....	....	....	....	....
Oil City	1.75	....	1.20	.78	....	....	....	1.20
Pittstown	**1.40	*6.54**	1.00	1.12	....	....	....	....
Scranton	2.00	1.50	1.25	....	15.75	....	....	....
Shamokin	....	1.00	.70	†18.00	....	....	....	....
Wilkes-Barre	1.60	1.75	1.25	1.35	....	....	....	....
Williamsport	1.70	1.25	1.25	....	....	....	....	1.25
York	1.80	1.10	[16].05½	....	20.00	....	....	....
Maryland—								
Baltimore	1.36	2.20	1.22	1.05	3.50	1.80	1.77	1.47
Frederick	1.55	1.00	1.50	....	....	....	....	....
East North Central Division:								
Ohio—								
Alliance	1.90	[17]1.10	1.25	.70	....	....	....	....
Cincinnati	1.70	2.00	1.40	.90	....	1.70	1.75	....
Columbus	1.40	1.25	1.25	†17.25	[18]20.95	....	....	1.25
Conneaut	**1.40	1.12½	....	18.00	....	....	...	1.12½
Dayton	1.80	....	1.00	[19].80	....	[20]1.60	1.40	1.25
Delaware	1.50	*.70	....	1.07	....	....	....	....
East Liverpool...	....	....	*.70	.75	....	....	....	*.65
Elyria	2.00	1.30	1.50	1.00	....	....	....	....
Fostoria	**1.35	1.15	1.45	....	....	....	....	....
Ironton	1.67	....	*.85	....	....	....	....	*.87
Lancaster	....	....	....	....	....	....	....	....
Lima	**1.80	1.20	1.50	.80	....	....	....	....
Mansfield	1.79	.92	.92	1.00	16.00	....	....	....
Massillon	2.15	1.40	1.50	.60	22.00	....	....	....
Middletown	**1.60	....	1.00	....	....	....	....	1.00
Newark	....	....	.75	....	....	....	....	.50
Painesville	1.90	1.76	1.50	.70	....	....	....	1.70
Portsmouth	1.65	....	1.00	.52	....	....	....	1.00
Punxsutawney ...	....	....	....	....	....	....	....	....
Sandusky	1.85	.70	1.25	.75	....	....	....	1.25
Steubenville	1.80	....	.81	.65	....	....	....	.81
Urbana	1.90	1.33	.80	.80	....	....	....	.75
Westerville	....	....	....	....	....	....	....	....
Youngstown	1.80	....	*[11]1.00	.70	....	....	....	*[11]1.00
Zanesville	1.50	....	.90	.68	....	....	....	.90
Indiana—								
Fort Wayne	1.30	1.50	1.25	.56	21.50	....	....	1.50
Frankfort	1.50	1.50	1.50	.80	36.00	....	....	1.50
Goshen	1.50	*1.13	.60	.80	22.00	....	....	.80
Huntington	1.80	1.25	1.15	....	22.00	....	....	1.15
La Porte	2.06	1.15	1.00	.90	....	....	....	1.15
Logansport	1.75	1.00	1.00	.90	22.00	....	....	1.00
Portland	....	....	[21]1.00	....	....	....	....	[21]1.00
South Bend	1.80	1.25	1.25	1.00	20.00	....	....	1.25
Terre Haute	....	1.10	.50	.80	....	....	....	....
Illinois—								
Belleville	1.41	1.00	1.00	....	....	....	....	....
Chicago Heights.	1.20	.90	1.00	.88	....	....	....	.90
Decatur	1.58	....	1.10	.72	....	....	....	1.25
Granite City	2.16	1.85	1.10	.60	....	....	....	1.80
Jacksonville	....	*1.15	.85	....	....	1.35	....	....
Mattoon	1.30	1.35	1.00	.75	....	....	....	1.00
Oak Park	1.61	1.65	1.65	.98	21.90	....	....	....
Ottawa	1.41	1.25	1.25	.78	22.00	....	....	1.25
Peoria	1.85	1.85	1.50	.84	....	....	....	...
Pontiac	1.64	1.10	1.15	.80	....	....	....	1.15
Rockford	1.62	.90	[7]1.00	.91	....	....	....	*1.15
Michigan—								
Ann Arbor	1.60	[22]1.20	1.00	.90	....	....	....	1.00
Battle Creek	1.25	...	...	.85	....	....	....	[23].25
Bay City	1.45	1.35	1.10	.85	22.00	....	....	1.15
Flint	1.444	....	1.30	.814	[24]28.44	....	....	1.70
Grand Rapids ...	1.90	[25]1.15	[7]1.10	1.30	[25]20.00	....	....	[25]1.00
Marquette	....	1.30	.50	....	16.80	...	....	.50
Negaunee	....	1.90	....	....	....	....	....	....
St. Joseph.......	1.80	1.26	1.00	.93	....	...	....	1.00
Wisconsin—								
Antigo	....	1.50	1.00	....	....	....	....	1.00
Appleton	....	....	....	....	....	....	....	....
Eau Claire	1.75	1.82	....	....	....	....	....	[26].80
Fond du Lac.....	1.60	1.00	1.00	....	18.00	....	....	....
Janesville	....	.90	...	....	†.13½	....	...	....
La Crosse	2.00	1.50	.50	24.00	22.00	....	....	....
Marinette	2.10	1.35	1.00	....	....	....	....	....
Merrill	2.08	1.25	.45	1.20	....	....	....	.45
Oshkosh	....	1.45	1.25	...	....	....	....	[27]1.45
Sheboygan	1.80	1.35	1.35	26.00	....	....	....	1.35
Stevens Pont ...	**1.80	2.00	1.25	1.08	....	....	....	1.40
Superior	1.85	1.70	.85	...	....	....	....	1.15
Watertown	....	1.10	....	....	....	....	....	....
West Allis	....	[25]1.65	[25]1.00	....	....	....	....	[28]1.05

TABLE X.—PREVAILING LOCAL PRICES FOR MATERIALS USED IN PAVEMENT CONSTRUCTION—(Continued).

	Portland cement, per bbl.	Broken stone, per cu. yd.	Sand, per cu. yd.	Paving brick, per sq. yd.	Asphalt, per ton.	Creosoted wood block, per sq. yd.	Granite block, per sq. yd.	Gravel, per cu. yd.
West North Central Division:								
Minnesota—								
Mankato	1.80	1.25	.75	....	....	....	....	....
New Ulm	2.00	1.25	.90	....	....	1.45	....	.90
Rochester	1.75	1.75	1.00	....	....	1.40	....	....
St. Paul	²⁹2.12	³⁰2.20	³¹1.15	1.06	16.40	1.48	....	³²1.84
Iowa—								
Dubuque	2.00	1.35	1.25	.90	....	1.50	....	1.50
Keokuk	**1.75	⁷1.60	⁷1.35	†19.00	25.00	....	....	....
Marshalltown	1.63	....	1.10	....	....	....	....	³³1.96
Mason City	1.70	1.60	1.00	....	23.00	....	....	1.60
Sioux City	1.60	2.25	1.05	....	....	....	....	....
Missouri—								
CapeGirardeau	**1.50	1.25	1.00	....	....	....		....
Independence	2.00	1.35	1.60	....	20.00	....	....	....
Joplin	³⁴2.10	³⁵.10	³⁶.25	.80	21.00	1.70	...	1.10
Moberly	2.23	2.00	1.05	†16.50	....	....	....	....
Springfield	....	1.50	1.80	....	23.00	...	...	....
South Dakota—								
Lead	3.20	1.00	3.00	....	....	...	...	....
Sioux Falls	1.65	1.30	1.10	....	22.00	..	....	....
Nebraska—								
......	1.60	³⁷*2.55	.70	.95	20.00	....	...	....
Norfolk	....	....	1.10	....	....	. .	....	1.25
York	1.80	....	*.70	....	....	....	....	*1.00
Kansas—								
Atchison	1.65	1.45	1.10	1.05	.18	...	....	....
Independence	1.50	1.40	1.80	.65	19.00	....	...	..
Manhattan	1.60	....	1.25	....	30.00	....	...	³⁸1.65
Topeka	1.75	1.60	.75	....	....	...	....	....
Wichita	1.67	1.60	.25	.80	18.00	....	....	....
North Dakota—								
Grand Forks	2.10	....	....	....	....	....	....	.43
Minot	2.50	....	...	...	....	2.67	...	1.00
South Atlantic Division:								
Virginia—								
Danville	1.97	1.30	.85	1.06	18.00	1.90	1.10	....
West Virginia—								
Clarksburg	2.25	3.25	3.00	.88	....	....	....	3.25
Huntington	2.75	1.25	1.25	.70	....	1.24	....	1.00
Martinsburg	2.60	.75	1.25	1.90	....	....	....	....
Moundsville	2.10	³⁹.65	.75	.70	....	....	....	.75
Morgantown	1.90	2.00	2.00	.95	....	...	....	....
Parkersburg	**1.46	....	.60	.80	....	....	....	.60
North Carolina—								
Charlotte	2.15	1.75	1.00	....	....	....	...	....
Concord	⁴⁰....	....	1.00	2.85	...	..	....	....
Durham	⁴¹....	2.50	1.00	....	....	....	...	...
Gastonia	2.15	*1.20	.75	....	....	....	....	....
Greensboro	2.17	1.75	1.00	....	....	....	....	....
Raleigh	....	⁷2.25	⁷1.00	....	....	...	....	⁴²1.00
Wilmington	2.25	2.28	.50	†30.00	....	...	....	1.50
South Carolina—								
Charleston	2.00	*2.00	1.00	....	....	....	...	....
Florida—								
St. Augustine	2.20	2.15	.75	....	....	....	...	...
Georgia—								
Americus	2.31	....	1.50	....	....	....	....	2.05
Macon	1.90	2.00	.75	....	....	....	....	....
Savannah	**1.80	*1.70	.70	....	....	....	1.02	....
East South Central Division:								
Kentucky—								
Bowling Green	2.15	⁷1.00	⁷2.00	....	⁴⁴6.00	....	....	1.00
Louisville	2.05	1.50	1.25	.72	21.00	1.80	2.15	1.40
Middleboro	....	1.00	1.35	....	....	...	....	....
Paducah	2.00	.95	.65	1.00	20.00	1.30	....	.75
Tennessee—								
Chattanooga	1.50	1.25	1.25	....	....	....	....	1.25
Clarksville	....	1.40	1.75	....	....	....	....	1.50
Jackson	2.40	2.10	.50	†24.00	....	....	....	.98
Memphis	1.90	1.20	1.25	....	20.00	1.25	....	.85
Mississippi—								
Vicksburg	2.40	4.00	.90	2.00	22.00	2.65	....	1.00
Alabama—								
Gadsden	1.76	1.00	1.35	....	. .	...	....	.
West South Central Division:								
Louisiana—								
Lake Charles	2.43	....	1.20	.36	....	....	....	1.85
Texas—								
Austin	2.20	....	.75	....	....	....	...	⁴⁵.75
Cleburne	1.90	1.35	1.60	....	....	....	....	1.45
Dallas	1.90	1.65	1.50	1.03½	17.00	⁴⁶1.78	....	1.50
Greenville	**1.83	2.10	2.00	....	....	....	....	1.45
Hillsboro	1.85	2.40	1.44	....	20.00	....	...	1.44
Longview	2.40	3.00	2.50	....	18.00	...	.	⁴⁷1.50
Mountain Division:								
Montana—								
Anaconda	2.40	1.60	1.35	....	....	....	...	1.25
Bozeman	2.60	1.75	2.00	....	21.00	....	..	1.75
Butte	2.19	1.75	1.50	....	....	...	.	.
Great Falls	2.77	....	1.50	....	....	.	....	1.75
Helena	2.30	1.50	1.52	1.50	..		..	.
Missoula	2.55	....	...	....	.	...	. .	. ..
Colorado—								
Colorado Springs	....	....	....	....	....	...	...	. .
Denver	2.41	1.65	1.00	1.35	20.00	. .	...	1.35
Pueblo	1.92	.70	.80	....	....	..	1.70	.75
Idaho—								
Boise	**3.20	1.50	.85	....	20.00	...	....	1.25
Wyoming—								
Cheyenne	2.40	...	....	....	...	...	...	....
Wilkes-Barre	1.50	.83	.50	....	....	.	....	...
Utah—								
Salt Lake City	2.00	1.50	.85	....	16.00	.	...	.85
Pacific Coast Division:								
California—								
Long Beach	2.75	2.25	1.40	†10.00	33.85			2.25
Los Angeles	2.10	1.20	.50	1.08	13.00		1.46	.95
Oakland	2.35	....	....	....	....	..	...	
Pomona	2.50	1.75	1.25	....	20.25		.	1.75
Riverside	**2.30	1.50	1.00	....	....	..	..	.70
San Diego	2.20	1.50	1.00	.	12.00		..	1.50
Santa Ana	2.20	1.75	1.50	. .			.	
Santa Barbara	2.50	1.75	1.05	....	15.00			1.65
Santa Rosa	2.50	1.50	1.35	....	13.25	....	....	1.25
Vallejo	2.05	1.10	1.25	....	12.00	..	...	2.00
Oregon—								
Salem	2.22	1.60	1.35	....	16.00	..		1.25
Washington—								
Aberdeen	2.30	....	1.50	....	15.00	..	. .	1.50
Everett	**2.40	....	1.40	...	....	..	.	1.40
Tacoma	**2.30	1.75	1.00	1.31	16.50	....	⁵2.00	1.00

*Ton. ‡Gal. †Per M. **Net. [1]1½ yds. delivered. [2]$2.45-2.55. [3]$0.85-1.05 per ton. [4]Load. [5]F. o. b. shipping point. [6]$1.82-2.12, paper, cloth. [7]Delivered. [8]From town bank. [9]In 1916. [10]With pitch filler. [11]F. o. b. [12]$0.90-1.30. [13]Crushed limestone. [14]F. o. b. cars. [15]Trap $2.40, limestone $1.50. [16]Bushel. [17]Broken slag. [18]$18.55 per ton for oil. [19]$0.70-80. [20]$1.50-1.60. [21]$0.75-1.00. [22]Pebbles. [23]Haul it ourselves. [24]$18.48 also. [25]On cars. [26]At screening plant. [27]Crushed. [28]Screened and washed. [29]$1.75-2.12. [30]$1.60-2.20 delivered on street. [31]$1.00-1.15 delivered on street. [32]$1.65-1.84 delivered on street. [33]F. o. b. city. [34]At gross. [35]Gravel tailings—10 ct. at pile. [36]At pile. [37]Broken granite. [38]$1.55-1.65. [39]Slag per ton f. o. b. [40]Gone up. [41]Variable. [42]Branch, delivered. [43]Petrum gravel, delivered work. [44]Kentucky rock. [45]Delivered on work. [46]$1.78-4 in., $1.65-3½ in. [47]Road gravel. $2.75 bank own concrete gravel mixed with sand; $2.75 screened and worked concrete gravel. [48]Per ton pit and freight. [49]$0.75-1.25. [50]Sandstone, $1.75.

TABLE XI AMOUNT AVERAGE PRICE AND DETAILS OF STONE BLOCK PAVEMENT LAID IN 1916 IN VARIOUS CITIES.

	Square yards.	Kind of filler.	Average price per sq. yd., including base and grading.	Guarantee, yrs.	Total thickness, ins.	Concrete base.	
						Thickness, in.	Proportions.
New England Division:							
Maine—							
Biddeford	¹6,000	......	$1.65	.	..	.	.....
Biddeford	²3,000	Grout	*.65	.	..	.	.....
Portland	4,639	Cement	2.31	.	5	.	.....
Portland	³3,824	Cement	2.02	.	11	4	1:2:4
Massachusetts—							
Cambridge	5,523	Grout	....	.	12	7	1:2½:5
Haverhill	⁴4,498	Grout	.94	.	..		....
Lawrence	8,595	Grout	....	.	..		.....
Lowell	12,982	Cement	....	.	12	6	1:3:6
Lynn	1,252	Grout	2.90	.	7	.	.....
Malden	9,800	Cement	3.17	5	11	6	1:3:6
Revere	1,542	Grout	3.73	.	.	6	1:3:6
Somerville	⁵6,448	Cement	2.36	.	10	5	1:3:6
Springfield	9,041	Pitch⁶	3.70	.	..	7	1:3:6
Connecticut—							
New Haven	¹33,750	......	1.65	5	6	.	.....
Rhode Island—							
Providence	16,067	Grout	*3.83			6	1:3:6
Providence	1,956	Sand	*3.00		..	.	....
Woonsocket	30,000	Cement	3.96	5	.		.....
Middle Atlantic Division:							
New York—							
Albany	⁷1,530	Sand	*1.40	5			.....
Albany	⁸3,881	Grout	*1.66	5	[illegible]	6	1:3:6
Albany	⁹39,079	Grout	*2.05	5	[illegible]		1:3:6
Albany	¹⁰32,391	Grout	*3.21	5	.	6	1:3:6
Albany	¹¹13,415	Grout	*2.81	5		6	1:3:6
Johnstown	510	Cement	3.10		10	4	1:3:6
Little Falls	669	Pitch	*3.75	5	12	7	1:2½:[illegible]
New Jersey—							
Bayonne	4,340	Cement	3.90	1	12	6	1:3:6
Passaic	1,800	.....	*3.60	5	12	6	1:3:6
Pennsylvania—							
McKees Rock	700	Grout	*3.25	.	[illegible]	6	[illegible]
Maryland—							
Baltimore	¹²28,418	Cement¹³	3.60	5	[illegible]	[illegible]	[illegible]
East North Central Division:							
Ohio—							
Cincinnati	7,760	....	3.54	2			1:3:6
Cincinnati	¹⁴10,200		2.00	[illegible]		.	.....
Cincinnati	[illegible]		3.00	[illegible]			.....
Dayton	[illegible]10,975	Cement	3.50	5	10	[illegible]	1:3:6
Wisconsin—							
Appleton	[illegible]1,880	Grout	[illegible]	.	[illegible]	[illegible]	[illegible]
West North Central Division:							
Minnesota—							
Duluth	[illegible]	Cement	[illegible]	5	14	6	[illegible]
St. Paul	[illegible]		.	.	..	.	.....
South Dakota—							
Sioux Falls	21,799		.	.	..	.	.....
South Atlantic Division:							
Virginia—							
Danville	700	Pitch	[illegible]	.	..	.	.....
Georgia—							
Savannah	4,983	Cement	1.85	.	6	.	...
East South Central Division:							
Kentucky—							
Louisville	24,774	[illegible]	*3.48	5	..	6	1:3:6
Mountain Division:							
Colorado—							
Denver	¹⁷12,000	Grout	[illegible]	5	6	.	...

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*Does not include grading.

[1]Hassam. [2]Old granite block relaid. [3]Split granite block relaid. [4]Relay. [5]Old blocks recut. [6]Pitch, cement, sand. [7]Second-hand granite block. [8]Second-hand granite block, 1½-in. sand cushion, on concrete. [9]Granite block, split and redressed, on 1-in. sand cushion. [10]Dressed granite block on 1-in. sand cushion. [11]Dressed and redressed block in car tracks on 1-in. sand cushion. [12]Sand-cement bed. [13]Cement and asphalt. [14]Old granite recent. [15]Limestone grouted. [16]Durax. [17]Sandstone. [18]$2.20 with sand filler. [19]Granite block; street railway.

HIGHWAY CONSTRUCTION BY COUNTIES IN 1916 AND WORK PROPOSED FOR 1917.

Details of Improvements Constructed and Contemplated in a Number of States Where the County Is in Charge of Construction.

OHIO.

ROAD CONSTRUCTION BY COUNTIES IN 1916.

Macadam.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, ins.	Average cost per mile including grading.
Allen	1.00	16	8	$ 9,500
Cuyahoga	1.25	8	8	4,000
Fairfield	15	9	9	4,520
Franklin	38	16	10	8,300
Hancock	30	10	7	5,000
Knox	6	14	7	1,200
Mahoning	21.63	14	8	7,842
Muskingum[1]	3	[2]14	7	[1]12,100
Summit	1⅛	14	7	8,900

[1] Bituminous. [2] 16 and 14 feet.

Brick.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, ins.	Average cost per mile including grading.
Allen[1]	1.75	17	10	$43,000
Cuyahoga	17.15	16†	8-9	23,934
Crawford	3¼	16	9	18,000
Franklin	2½	..	..	.....
Hancock	16	16	9	2,000
Knox	4	[2]16	10	22,000
Mahoning[1]	1.09	24	[3]4	33,290
Muskingum	1½	16	10	19,600
Scioto	6	16	10½	22,000
Summit	18.61	16	8	22,000
Wayne	10	10	8	15,000

[1] Monolithic. [2] 14-16 feet. [3] Base.

Concrete.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, ins.	Average cost per mile including grading.
Allen[1]	..	18	7	$ 6,500
Cuyahoga	5.9	16	7	25,854
Fairfield	2½	16	7	1,300

[1] Reinforced.

Bituminous.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, ins.	Average cost per mile including grading.
Allen[1]	3.10	16	8	$30,500
Allen	2.1	16	8	19,000
Cuyahoga	3.0	18	10	29,498
Hancock	5	16	2	8,000
Mahoning[3]	2.2	16	2½	5,083

[1] Asphalt-macadam. [2] Glutrin bound macadam. [3] Resurfacing old macadam.

PROBABLE ROAD CONSTRUCTION BY COUNTIES FOR 1917.

County.	Gravel, miles.	Macadam, miles.	Brick, miles.	Concrete, miles.	Bituminous.
Allen	..	1.20	3.50	26	....
Butler[1]	..	...	12½	1½	....
Cuyahoga	3.2	[2]5.14	15.53	7.02	5.32
Crawford	..	6¾	..	..	....
Fairfield	..	20	..	½	....
Hancock	..	[2]25	6	3	....
Knox	..	[4]4½	..	[4]5	....
Mahoning[6]	..	15	[5]8.2	..	....
Muskingum	..	[7]3	[8]14	..	....
Scioto[9]	..	..	4	..	....
Summit	..	[10]2.33	[11]20	..	....
Wayne	..	1½	10	..	....

[1] Bids were received Dec. 21, 1916. [2] Water bound. [3] 14 feet. [4] 14 and 16 feet. [5] Also brick resurfacing 1 mile. [6] Bituminous resurfacing 1 mile. [7] Tar bound. [8] Brick or concrete. [9] Bituminous macadam 4 miles. [10] Water bound. [11] 16 feet monolithic.

AMOUNTS AVAILABLE IN 1916 AND PROBABLE AMOUNTS FOR 1917.

County.	Amount available in 1916.	Amount available in 1917.
Butler	......	$300,000
Crawford	$ 48,000	26,000
Fairfield	......	......
Hancock	......	......
Knox	114,000	125,000
Lorain	......	......
Mahoning	......	......
Muskegon	154,000	300,000
Scioto	150,000	146,000
Summit	......	600,000
Wayne	140,000	77,000

INDIANA.

ROAD CONSTRUCTION BY COUNTIES IN 1916.

Gravel.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, ins.	Average cost per mile including grading.
Clay	2¼	9	12	$3,510
Delaware	27.2	[1]16	1	3,200
Marion	3.1	14	12	5,000
Tippecanoe	13	9	12	3,800

[1] 14 to 16 feet.

Macadam.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, ins.	Average cost per mile including grading.
Delaware	11.7	20	1	$9,000
LaPorte	17½	..	9	5,000
Marion	2	11	12	9,000
Tippecanoe	2	12	10	4,500

Brick.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, ins.	Average cost per mile including grading.
Clay	[1]2	16	9	$25,200
Delaware	.5	20	11	21,500
LaPorte	3	..	..	18,000

[1] Monolithic.

Concrete.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, ins.	Average cost per mile including grading.
Delaware	1.1	18	7	$15,100
Marion	15.8	18	7	17,000

PROBABLE ROAD CONSTRUCTION BY COUNTIES FOR 1917.

County.	Macadam, miles.	Brick, miles.	Concrete, miles.	Bituminous, miles.	Gravel, miles.
Clay[1]	2¾	½	..	..	..
Delaware	4	9.8	1	22.6	18.5
LaPorte	25	4½	..	..	7
Marion	4.5	1.5	21	2.5	5
Tippecanoe	..	[1]21	..	..	15

[1] Brick and concrete.

AMOUNTS AVAILABLE IN 1916 AND PROBABLE AMOUNTS FOR 1917.

County.	Amount available in 1916.	Amount available in 1917.
Clay	$ 60,000	$ 60,000
Delaware	875,000	170,000
LaPorte	......	......
Marion	......	......
Tippecanoe	......	100,000

ILLINOIS.

ROAD CONSTRUCTION BY COUNTIES IN 1916.

Earth.

County.	Miles.	Surfaced width, ft.	Average cost per mile including grading.
Alexander	18	20	$ 300
Bond	250	..	....
Brown	100	24	50
Christian	9.8	15	[1]2,635
Fulton	5	24	1,200
Henry	18	24	....
Jasper	5	[2]24	[3]1,600
Lake	20	20	125
McDonough	200	24	35
Marion	5½	..	2,233
Marshall	4½	30	2,649
Montgomery	13	..	1,300
Stephenson	[4]100	..	....
White	[4]250	..	12

Christian Co. Earth Oiled.

[1] Bridge and culverts.

[2] Width of roadway.

[3] Grading and culverts.

[4] Grading only.

Gravel.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, ins.	Average cost per mile including grading.
Alexander	2	15	7	$5,000
Lake	20	10	..	3,000
Lawrence	20	[1]12	9	4,000
Lee	2	9	9	3,000
McHenry	4	10	12	6,000
Stephenson	2	12	..	3,000
White	12	10	9	3,000
Whiteside	4½	10	10	6,000

[1] 9 and 12 ft.

Macadam.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, ins.	Average cost per mile including grading.
Iroquois	2	10	10	$ 6,000
Lake	10	10	..	4,000
Lee	4	10	9	3,500
Madison	⅞	12	8	6,000
Stephenson	1⅛	15	8	10,000
Williamson	5.6	15	7	14,000

Bituminous.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, ins.	Average cost per mile including grading.
Grundy	1½	[1]..	..	....
Iroquois[2]	9	10	8	$8,100

[1] State aid some 10 ft. and some 15 ft. wide. [2] Macadam.

Brick.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, ins.	Average cost per mile including grading.
Bond	¾	10	6	....
Iroquois	6¼	9	5	$ 8,400
Lawrence	1	15	..	13,000
Lee	2¾	17½	..	....
Lee	2	10	..	....
Marshall	⅔	10	6½	12,355
Pratt	3	9	4	11,785
Vermilion	7½	10	[1]9	12,985
Vermilion	9	10	..	12,500
Whiteside	3	18	..	17,000

[1] 8-9 in.

Concrete.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, ins.	Average cost per mile including grading.
Cook	21.6	18	7	....
Fulton	1½	15	..	$15,000
Grundy	[1]70	..	7	....
Henry	2½	15	6	13,600
Lake	⅞	15	7	13,000
Madison	2½	10	7	7,500
Madison	2	15	7½	11,300
Menard	2 1/5	..	7	....
Vermilion	42½	10	6	8,214
Williamson	14.9	10	..	10,500
Williamson	19.4	15	..	14,000
Winnebago	2	18	7	13,700

[1] 6-7 in.

PROBABLE ROAD CONSTRUCTION BY COUNTIES FOR 1917.

County.	Earth, miles.	Gravel, miles.	Macadam, miles.	Brick, miles.	Concrete, miles.
Alexander	[1]20	3	..	..	..
Bond	..	..	..	¾	..
Brown	100	..	..	..	..
Christian	6½	..	..	..	..
Cook	..	..	..	..	..
Fulton	5	..	..	1	1½
Grundy	..	..	..	..	[2]1½
Henry	18	..	..	..	..
Iroquois	..	..	2	4	..
Jasper	..	..	..	..	..
Lake	50	50-20	10	..	2
Lawrence	..	40	..	..	1
Lee	..	5½	3	1.2	..
Logan	..	20	..	..	..
McDonough	12	..	..	..	..
McHenry	..	4¼	..	..	..
Madison	..	..	..	..	8
Marion	4	..	..	..	..
Marshall	[4]4	..	..	..	..
Menard	[3]63	..	..	..	1½
Montgomery	15	..	..	..	..
Peoria	..	..	..	1	9½
Pratt	..	..	..	[6]4½	..
Scott	3	..	..	..	..
Stephenson	..	..	..	[5]1½	..
Vermilion	..	..	..	15	102
Vermilion	..	..	..	22	103
White	250	..	14	..	..
Whiteside	[7]5	34	..	..	1
Williamson	4½	..	..	..	..
Winnebago	..	..	¼	..	1⅞
Woodford	[8]15	..	..	..	..

[1] 18 to 20 miles. [2] 1½ miles state aid 10 ft. wide. [3] Oiled earth. [4] Grading and drainage. [5] Monolithic brick. [6] $23,500, 8 ft. brick, 4 ft. concrete shoulders. [7] Grading only. [8] 15 miles state aid, oiled, 15 ft. wide.

AMOUNTS AVAILABLE IN 1916 AND PROBABLE AMOUNTS FOR 1917.

County.	Amount available in 1916.	Amount available in 1917.
Alexander	$ 30,000	$ 35,000
Bond	......	30,000
Brown	59,000	59,000
Christian	25,824	25,824
Cook	1,800,000	1,000,000
Fulton	25,000	25,000
Henry	2,600	52,000
Iroquois	[2]140,000	13,000
Jasper	8,104	......
Lake	......	108,000
Lawrence	155,000	192,000
Lee	87,500	75,000
Logan	......	75,000
McDonough	108,000	126,000
McHenry	24,000	25,000
Madison	86,000	86,000
Marion	73,228	75,745
Marshall	12,236	12,236
Menard	40,000	44,000
Montgomery	22,000	22,000
Peoria	......	143,000
Pratt	17,723	2,300
Scott	[3]25,000	[3]24,000
Stephenson	90,000	100,000
Vermilion	500,000	1,100,000
White	79,500	79,000
Whiteside	180,000	208,000
Williamson	242,314	20,000
Winnebago	28,000	36,000
Woodford	......	65,000

[1] County and state aid together. [2] For hard roads. [3] In road districts.

MICHIGAN.

ROAD CONSTRUCTION BY COUNTIES IN 1916.

Earth.

County.	Miles.	Surfaced width, ft.	Av. cost per mile, including grading.
Kalamazoo	[1]3	..	$2,000
Marquette	[1]4	22	2,705
Mecosta	[1]3	..	1,000
Newaygo	30	16	200
Ottawa	[1]4	24	500
St. Clair	[1]11.83	24	....

[1] Grading only.

Gravel.

County.	Miles.	Surfaced Width, ft.	Av. Thickness Surfacing, ins.	Av. Cost per Mile Including Grading.
Calhoun	20	[1]16	8	$3,500
Cass	16	9	9	3,000
Crawford	2	9	8	3,000

Genesee ..	30	9	10	3,200
Grand Traverse ...	15	12	12	....
Jackson ..	25	[1]16	8	500
Kalamazoo.	6½	16	8	6,000
Lapeer	10	9	8	4,000
Macomb ..	426	[1]16†	4	6,000
Marquette.	5.75	15	6	1,790
Mecosta ..	3	9	9	2,300
Mecosta ..	3	15	9	2,700
Missaukee..	5	[2]12	10	2,250
Montcalm .	26	9	8	1,700
Newaygo .	20	9	8	2,000
Ottawa ...	10	9	8	4,000
St. Clair ...	6.52	9	8	....

[1] 9-16 ft.
[2] 9-2 ft.

Macadam.

County.	Miles.	Surfaced Width, ft.	Av. Thickness Surfacing, ins.	Av. Cost per Mile Including Grading.
Berrien ...	49.4	[1]16	6	$7,940
Crawford[2]..	1	16	8	4,500
Grand Traverse ...	2	12	[5]10	....
Kalamazoo.	2½	9	8	4,800
Macomb[3] .	42.6	[1]16	4	6,000
Marquette[4].	4.92	..	..	1,875
St. Clair...	6.78	[6]16	6	....
Washtenaw	8	[7]16	8	3,500

[1] 12 and 16.
[2] Limestone.
[3] Also gravel.
[4] 9-16 ft.
[5] Resurfacing.
[6] 9-8-16 ft.
[7] 9-12-16 ft.

Concrete.

County.	Miles.	Surfaced Width, ft.	Av. Thickness Surfacing, ins.	Av. Cost per Mile Including Grading.
Calhoun ..	2	16	7½	$13,000
Ottawa ...	3	8	6	5,500

PROBABLE ROAD CONSTRUCTION BY COUNTIES FOR 1917.

County.	Gravel. Miles.	Macadam. Miles.	Concrete. Miles.
Berrien	..	[1]15	..
Calhoun	[2]40	10	[3]6
Cass	..	..	..
Crawford	..	..	..
Genesee	[4]50	..	[5]20
Grand Traverse ...	10	..	[6]50
Jackson	..	..	..
Kalamazoo[7]	5½	2	2¾
Kalkaska	10	..	..
Lapeer	[8]20	..	..
Lake	..	..	..
Macomb	..	..	..
Marquette[10]	7¾	[9]4	..
Mecosta	8	..	..
Missaukee	7	..	..
Montcalm	..	..	..
Newaygo	20	..	..
Ottawa	8	..	3
St. Clair..........	8½	2¼	[11]9¾
Washtenaw	14	..	..

[1] 16 ft. wide, 8 in. deep and $40,000 for maintenance.
[2] 20 to 40 miles.
[3] Brick or concrete.
[4] 9 ft.
[5] 16 ft.
[6] We are to vote April 2 on bond issue of $900,000.
[7] Bituminous asphaltic.
[8] Gravel 9 ft. and 16 in.
[9] Also resurfacing 4 miles.
[10] Sand clay 2 miles.
[11] Or bituminous.

AMOUNTS AVAILABLE IN 1916 AND PROBABLE AMOUNTS FOR 1917.

	Amount available in 1916.	Amount available in 1917.
Berrien	343,200	193,000
Calhoun	96,000	800,000
Cass	34,000	......
Crawford	10,000	10,000
Genesee	......	1,000,000
Jackson	127,000	......
Kalamazoo	100,000	100,000
Kalkaska	[1]4,000	[1]4,000
Lapeer	[2]......	[2]......
Lake	......	......
Macomb	100,000	250,000
Marquette	500,000	81,600
Mecosta	[3]18,000	30,000
Missaukee	12,000	14,000
Montcalm	......	......
Newaygo	......	......
Ottawa	100,000	92,000
St. Clair	675,000	83,000
Washtenaw	47,000	66,000

[1] $3,000 or $4,000.
[2] Assessment plan.
[3] $14,000 and reward.

WISCONSIN.

ROAD CONSTRUCTION BY COUNTIES IN 1916.

Earth.

County.	Miles.	Surfaced width, ft.	Av. cost per mile, including grading.
Adams	15	..	$ 450.00
Barron	16		1,144.04
Crawford	7		....
Douglas	35	..	20.36
Dunn	..	..	....
Eau Claire	[1]1.04	22	2,870.00
Fond du Lac..........	..	..	....
Forest	22	..	2,150.00
Green	..	..	....
Green Lake	..	..	....
Iron	5	10	3,300.00
Jefferson	..	..	....
Juneau	..	..	....
Kewanee	..	..	....
La Crosse	..	..	....
La Fayette	23	..	....
Milwaukee	..	.	....
Monroe	3.6	..	1,300.00
Ozaukee	..	..	....
Price	31	28	800.00
Rock	..	..	....
Sauk	..	..	....
Sawyer	2.1	24	1,000.00
Trempealau	25	..	800.00
Walworth	..	..	....
Washburn	25	..	900.00
Waupaca	..	..	....
Winnebago	..	..	....

[1] Grading only.
[2] Average thickness surfacing inches, 12".

Sand-Clay.

County.	Miles.	Surfaced Width, ft.	Av. Thickness Surfacing, ins.	Av. Cost per Mile Including Grading.
Eau Claire	8.57	9	9½	$ 26.10

Gravel.

County.	Miles.	Surfaced Width, ft.	Av. Thickness Surfacing, ins.	Av. Cost per Mile Including Grading.
Douglas ..	3	9	6	$1,941.00
Dunn	9½	[1]15	[2]10	2,600.00
Eau Claire	1.81	9-15	8	39.60
Fond du Lac	1	..	..	....
[3]Green	2	..	9	....
Green Lake	1.53	9	11	1,600.00
Jefferson ..	12	[4]15	10	3,000.00
Juneau ...	10	9	11	3,500.00
Kewanee ..	5	9	10	2,000.00
Price	2	18	..	1,100.00
Rock	35	..	..	....
Walworth .	2½	9	10	2,647.00
Washburn .	4	9	10	1,405.00
Waupaca .	12	9	10	2,000.00

[1] 9 to 15 ft.
[2] 3 to 10 inches.
[3] Surfaced width, ft. crushed gravel.

Macadam.

County.	Miles.	Surfaced Width, ft.	Av. Thickness Surfacing, ins.	Av. Cost per Mile Including Grading.
Adams ...	1½	9	11	$5,322.00
Douglas ..	¾	9	..	2,314.00
Fond du Lac	12.5	..	..	....
Green	15.37	[1]..	9	[2]........
Green Lake	4.83	[3]18	12	3,300.00
Juneau	10	9	11	3,500.00
[4]Kewanee .	1½	9	10	2,500.00
La Crosse.	32	9	9	3,800.00
La Fayette.	3	..	..	....
Monroe ...	6.25	10.2	[5]11	5,440.00
Ozaukie ..	5	15	8	3,800.00
Rock	2	..	..	....
Sauk	16	15	8	3,750.00
Trempealeau	7	9	9	2,500.00
Trempealeau	7	15	9	4,000.00
Walworth .	6½	[5]15	10	4,290.00
Waupaca ..	6	9	9	3,600.00
Winnebago.	5	9	..	....

[1] Surfaced width, ft. crushed rock.
[2] Approx. 50c per sq. yd.
[3] 9x18 ft.
[4] Stone, loose.
[5] 9-15 ft.

Bituminous.

County.	Miles.	Surfaced Width, ft.	Av. Thickness Surfacing, ins.	Av. Cost per Mile Including Grading.
Trempealeau	½	45	9	... .

Brick.

County.	Miles.	Surfaced Width, ft.	Av. Thickness Surfacing, ins.	Av. Cost per Mile Including Grading.
Sauk	6	18	..	[1]
Trempealeau	¼	18	..	[1]......

[1] $1.57 per sq. yd.

Concrete.

County.	Miles.	Surfaced Width, ft.	Av. Thickness Surfacing, ins.	Av. Cost per Mile Including Grading.
Eau Claire.	1	9-15	6	$9,420.00
Green	[1]1	..	[2]6½	....
Jefferson .	1½	[3]	7	....
Milwaukee..	19.58	18	7	16,300.00
Monroe ...	1	9	6½	9,260.00
Rock	½	..	..	....
Sauk	½	15	[4]6	[5]
Winnebago.	1	[6]9		

[1] 9.838 sq. yds.
[2] 6" on edge approx. to 130 sq. yds. by 7" center per —
[3] 1.30 sq. yd.
[4] 6 and 7 inches
[5] 1.17½ sq. yd.
[6] 9 and 18 ft.

AMOUNTS AVAILABLE IN 1916 AND PROBABLE AMOUNTS FOR 1917.

County.	Amount available in 1916.	Amount available in 1917.
Adams	9,000	11,875
Barron	31,600	38,900
Crawford	20,550	23,750
Douglas	114,906	109,496
Dunn	13,832	14,000
Eau Claire	38,000	52,271
Fond du Lac	65,000	65,000
Forest	73,000	150,000
Green	86,829	81,883
Green Lake	33,068	36,000
Iron	48,000	53,000
Jefferson	80,000	96,000
Juneau	42,092	40,000
Kewaunee	32,000	30,000
La Crosse	130,000	155,000
La Fayette	48,000	62,000
Milwaukee	503,185	446,000
Monroe	66,000	72,000
Ozaukee	22,500	27,000
Price	38,974	38,000
Rock	100,000	100,000
Sauk	74,066	101,161
Sawyer	20,000	22,000
Trempealeau	85,000	100,000
Walworth	52,000	63,000
Washburn	25,000	35,000
Waupaca	60,000	80,000
Winnebago	45,000	60,000

PROBABLE ROAD CONSTRUCTION BY COUNTIES FOR 1917.

County.	Earth Miles.	Gravel Miles.	Macadam Miles.	Brick Miles.	Concrete Miles.
Adams	..	..	1¾	..	..
Barron	25	..	..	..	..
Crawford ...	10	..	..	..	..
[1]Douglas ...	30	10	2	..	3
Dunn	..	..	..	.	..
Eau Claire ..	1	3½	..		2½
Fond du Lac	..	..	15	..	1
[3]Forest	50	..	[2]5	..	..
Green	..	..	..	..	..
Green Lake.	[4]1	2	6	.	..
Iron	28	7	..	.	..
[5]Jefferson ...	..	15	4	.	½
Juneau	..	..	10	.	..
[6]Kewaunee ..	..	.	..	..	..
[7]La Crosse ..	..	.	..	.	..
La Fayette .	40	4	..	..	½
Milwaukee ..	..	.	..	.	23
[8]Monroe	4	..	5	.	1.5
Ozaukee	..	..	5	.	..
Price	30	2	..	..	..
Rock	..	36	3	..	½
Sauk	6	..	24	.	1½
Sawyer	[9]25	..	..	..	..
Trempealeau.	30	..	10	..	..
Walworth ..	..	2	8	½	1
[10]Washburn .	35	4	..	..	..
Waupaca ...	..	12	4	.	..
Winnebago .	..	..	6	..	2½

[1] 5 miles sand-clay.
[2] Pit run.
[3] Concrete, heavy grading.
[4] Grading only.
[5] 1 mile sand clay.
[6] Gravel; mostly gravel macadam.
[7] Macadam, lime stone.
[8] Shale 4.5 miles.
[9] Also 50 miles grading only.
[10] 8 miles sand clay.

MINNESOTA.

ROAD CONSTRUCTION BY COUNTIES IN 1916.

Earth.

County.	Miles.	Surfaced width, ft.	Av. cost per mile, including grading.
Aiken	30	14	$2,000.00
Anoka	10	..	600.00
Beltrami	9	..	1,055.00
Cass	70	[1]12	3,000.00
Chippewa	21	..	1,000.00
Clearwater	15	20	1,400.00
Itasca	15		1,000.00
Jackson	26		....
Kandiyohi	18		....
Le Sueur	18.3	.	....
Marshall	35	24	930.00
Morrison	30	.	55,000.00
Murray	53		42,400.00
Norman			700.00
Pope	12		....
Rock	4	.	1,250.00
Stevens	15		865.93
Todd	8	[2]20	740.00
Winona	10	24	700.00

[1] 12-20.
[2] 20-24.

Gravel.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, inches.	Av. cost per mile, including grading.
Aitken	6	16	6	$3,500.00
Anoka	6	[1]14	8	[illegible]
Brown	2.9	8	6	2,781.00
Beltrami	20	8	[illegible]	2,500.00
Chisago	32	24	6	3,500.00
Clearwater	2	16		2,000.00
Cook	[illegible]		.	2,700.00
Isanti	[illegible]	16	[illegible]	4,000.00
Itasca	[illegible]	10	6	1,500.00
Kandiyohi	10	8	.	1,461.00
Le Sueur	6.3	16	[illegible]	[illegible]
Meeker	20	[3]12	6	1,500.00
[illegible]	[illegible]	8	[illegible]	1,500.00
Ramsey	1	24		....
Scott	18.2	[4]16	6	2,200.00
Washington ..	[illegible]	16	6	[illegible]
Winona	18	8	6	4,000.00

[1] 6-14 ft.
[2] Gravel only.
[3] 8-12.
[4] 12—16.

Macadam.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, inches.	Av. cost per mile, including grading.
Itasca	6	10	6	$2,500.00
Winona	15	8	8	6,000.00

Bituminous.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, inches.	Av. cost per mile, including grading.
Ramsey	5.75	16	3	$4,000.00

Brick.

County.	Miles.	Surfaced width, ft.	Average thickness surfacing, inches.	Av. cost per mile, including grading
Winona	2	8	8	$17,000.00

PROBABLE ROAD CONSTRUCTION BY COUNTIES FOR 1917.

County.	Earth, miles.	Sand-clay, miles.	Gravel miles.
Aitken	10	60	[1]10
Anoka	10	3	[1]10
Beltrami	7	..	2½
Brown	..	..	15
Cass	..	..	....
Chippewa	16	1	1
Clearwater	10	..	5
Cook	21	..	....
Hubbard	20	..	....
Isanti	..	..	10
Itasca	10	..	15
Jackson	..	..	....
Kandiyohi	28¾	..	8
Lac Qui Parle	32	..	5
Le Sueur	20	..	10
Lyon	..	..	....
Marshall	40	..	30
Meeker	..	..	30
Morrison	[3]30	..	[4]16
Murray	55	..	....
Norman	..	..	....
Polk	..	..	....
Pope	1 3/10	..	....
Ramsey	[5]11.8	8.1	2.5
Rock	19	..	....
Scott	..	..	15
Stevens	25	..	1
Todd	23	15	4
Waseco	20	..	4½
Washington	..	..	10
Winona	..	..	45

AMOUNTS AVAILABLE IN 1916 AND PROBABLE AMOUNT FOR 1917.

County.	Amount available in 1916.	Amount available in 1917.
Aitken	$ 91,000	$ 20,350
Anoka	30,000	30,000
Beltrami	85,000	20,000
Brown	30,000	38,000
Cass	210,000	20,000
Chippewa	23,000	33,000
Chisago	....	110,000
Clearwater	25,165	24,000
Cook	....	....
Cook	22,000	47,000
Hubbard	10,500	10,000
Isanti	20,000	28,000
Itasca	80,000	60,000
Jackson	40,000	40,000
Kandiyohi	24,754	33,500
Lac Qui Parle	40,000	60,000
Le Sueur	26,000	40,000
Lyon	....	....
Marshall	40,000	60,000
Meeker	40,000	50,000
Morrison	70,000	70,000
Murray	55,000	60,000
Norman	28,000	30,000
Polk	30,000	30,000
Pope	35,000	30,000
Ramsey	....	163,000
Rock	31,000	26,000
Scott	40,000	30,000
Stevens	17,263	31,121
Todd	35,000	43,000
Waseca	....	39,000
Washington	35,000	51,500
Winona	300,000	300,000

MISSOURI.

ROAD CONSTRUCTION BY COUNTIES IN 1916.

Earth.

County.	Miles.	Surfaced width, ft.	Av. cost per mile, including grading.
Butler	100	25	$ 750
Jackson	[1]12¾	40	5,442
Marion	[2]115	[1]24	35

[1]Grading only. [2]Grading only.

Gravel.

County.	Miles.	Surfaced width, ft.	Av. thickness surfacing, in.	Av. cost per mile, including grading.
Butler	5	10	..	$1,000
Marion	4.5	12	12	2,100

Macadam.

County.	Miles.	Surfaced width, ft.	Av. thickness surfacing, in.	Av. cost per mile, including grading.
Jackson	10¼	18	7	$7,914
Marion	1	10	10	3,747

Bituminous.

County.	Miles.	Surfaced width, ft.	Av. thickness surfacing, in.	Av. cost per mile, including grading.
Jackson	5¼	24	8	$13,266

Concrete.

County.	Miles.	Surfaced width, ft.	Av. thickness surfacing, in.	Av. cost per mile, including grading.
Jackson	½	22	5¾	$15,144

PROBABLE ROAD CONSTRUCTION BY COUNTIES FOR 1917.

County.	Earth, miles.	Gravel, miles.	Macadam, miles.
Buchanan	[1]20	..	...
Butler[2]	100	..	...
Jackson	...	..	...
Marion	100	[1]12	3.5

[1]Grading only. [2]$300,000 bond issue contemplated.

AMOUNTS AVAILABLE FOR 1916 AND PROBABLE AMOUNTS FOR 1917.

County.	Amount available in 1916.	Amount available in 1917.
Buchanan	$165,171	$170,000
Butler	30,000	35,000
Jackson	554,000	600,000
Marion	65,000	65,000
Randolph	....	....

OKLAHOMA.

ROAD CONSTRUCTION BY COUNTIES IN 1916.

Earth.

County.	Miles.	Surfaced width, ft.	Av. cost per mile, including grading.
Beckham	36	24	$135.00
Craig	114	16	200.00
Delaware	63	20	400.00
Garfield	[1]23	..	37.50
Greer	40	32	55.00
Major	5	20	500.00
Okfuskee	200	..	100.00
Payne	100	20	300.00
Wagoner	24	..	....
Woods	42	21	38.50

[1]Grading only; tractor.

Sand-Clay.

County.	Miles.	Surfaced width, ft,	Av. thickness surfacing, in.	Av. cost per mile, including grading.
Major	4	20	8	$800
Payne	5	20	..	500

PROBABLE ROAD CONSTRUCTION BY COUNTIES IN 1917.

County	Earth, miles.	Sand-clay, miles,	Gravel, miles.	Concrete, miles.
Beckham	100	5	..	..
Caddo	...	..	..	..
Craig	[1]60	4	..	2
Delaware	20	..	..	..
Garfield	[2]30	..	..	..
Greer	[3]40	10	10	..
Major	8-10	8-10	..	..
Muskogee	...	..	..	..
Okfuskee	250	20	..	..
Payne	100	5	..	..
Wagoner	20	..	..	..
Woods	100	20	..	..

[1]Also 40 miles grading only. [2]Grading only. [3]Grading only, 15 miles.

AMOUNTS AVAILABLE IN 1916 AND PROBABLE AMOUNTS FOR 1917.

County.	Amount available in 1916.	Amount available in 1917.
Beckham	$ 10,000	$ 10,000
Caddo	....	....
Craig	41,000	4,100
Delaware	....	10,000
Garfield	17,000	17,300
Greer	3,500	....
Major[1]	30,000	35,000
Muskogee	50,000	50,000
Okfuskee	....	....
Payne	99,000	115,000
Wagoner	9,000	9,000
Woods	22,000	22,000

[1]And bridges.

IOWA.

ROAD CONSTRUCTION BY COUNTIES IN 1916.

Earth.

County.	Miles.	Surfaced width, ft.	Av. cost per mile, including grading.
Adair	..	..	....
Buchanan	[2]37	..	$ 108
Buena Vista	55	..	...
Calhoun	35	..	1,070
Cerro Gordo	[1]22	..	1,700
Clayton	4¼	20	1,270
Crawford	[2]25	..	2,600
Decatur	35	..	400
Dallas	78	25	82
Floyd	30	..	206
Greene	3	..	[4]1,000
Grundy	60	[5]36	125
Hardin	28	..	800
Harrison	45.5	..	500
Jefferson	40	36	300
Johnson	[1]50	..	500
Lyon	[3]52	..	165
Madison	[1]23	24	62
Marion	[1]2	..	....
Monona	[1]3	..	....
O'Brien	17	[6]36	1,000
Osceola	8	..	800
Palo Alto	19½	..	800
Pottawattomie	[1]245	24	121
Pocahontas	20	..	750
Sac	[1]30	..	1,000
Scott	4	..	15
Sioux	[6]80	24	104
*Sioux	[7]100	[8]22	[9]125
Story	30	..	....
Tama	[1]15	..	2,000
Webster	..	..	....
Woodbury	1½	..	2,800

[1]Grading only.
[2]325,000 cu. yds. of grading.
[3]Grading only with tractor.
[4]÷
[5]From ditch for tractor work.
[6]Ditch to ditch.
[7]Tractor.
[8]14 to 22.
[9]25 to 125.

Gravel.

County.	Miles.	Surfaced Width, ft.	Av. Thickness Surfacing, ins.	Av. Cost per Mile Including Grading.
Buchanan	3	16	6	$12,000
Buena Vista	22	10	7	800
Calhoun	10¼	16	6	2,255
Clayton	¼	26	..	3,600
Dallas	12	10	5	600
Greene	19	..	..	700
Hardin	12	[1]10	5	750
Osceola	1	10	8	1,750
Pocahontas[1]	13	..	..	575
Sac	[illegible]	..	..	1,900
Scott	2½	10	10	5,154
Story	26	9	6	1,500
Webster	1½	12	5	1,200

[1]Surfacing only.

AMOUNTS AVAILABLE IN 1916 AND PROBABLE AMOUNTS FOR 1917.

County.	Amount available in 1916.	Amount available in 1917.
Adair	26,000	17,000
Buchanan	33,000	33,000
Buena Vista	50,000	50,000
Calhoun	46,000	54,000
Cerro Gordo	40,000	47,000
Clayton	47,700	50,000
Crawford	62,000	77,000
Dallas	30,000	45,000
Decatur	16,000	17,500
Floyd	29,222	30,000
Greene	27,598	40,000
Grundy	30,000	28,000
Hardin	40,000	45,000
Harrison	35,000	35,000
Jefferson	36,500	20,000
Johnson	30,000	30,000
Lyon	29,000	35,000
Madison	20,937	21,088
Marion	35,000	35,000
Monona	40,000	45,000
Montgomery	20,000	20,000
O'Brien	40,000	42,000
Osceola	20,000	20,000
Palo Alto	40,000	42,000
Pottawattomie	66,637	66,000
Pocahontas	46,000	52,000
Sac	45,000	50,000
Scott	30,000	24,000
Sioux	25,500	26,000
Story	30,000	30,000
Tama	90,000	95,000
Webster	36,000	48,000
Woodbury[1]	70,000	70,000

PROBABLE ROAD CONSTRUCTION BY COUNTIES FOR 1917.

County.	Earth. Miles.	Gravel. Miles.
Adair	..	..
Buchanan	40	..
Buena Vista	72	25
Calhoun	25	20
Cerro Gordo[1]	..	..
Clayton	5	½
Crawford	[2]36	..
Dallas	[3]125	[4]20
Decatur	30	..
Floyd	20	20
Greene	20	20
Grundy	..	..
Harden	60	30
Harrison	..	..
Jefferson	50	..
Johnson	[5]25	..
Lyon	..	10
Madison	..	..
Marion	..	..
Monona	..	..
Montgomery	..	[6]3
O'Brien	..	..
Osceola	[7]17	..
Palo Alto	[8]33	..
Pottawattomie	..	..
Pocahontas	[1]40	20
Sac	..	[9]15
Scott	6	..
Sioux	[10]250	..
Story	..	..
Tama	30	20
Webster	..	..
Woodbury	..	44

[1]4 miles of concrete road; also 28 miles of grading only.

[2]456,392 cu. yds. grading let out; average price, 19.184 cts. per cu. yd.; expects to let 200,000 cu. yds. additional.

[3]Tractor blading.

[4]10-ft. surface per cent.

[5]To standard sections.

[6]Heavy grading; grading only 80 minutes; blade grader and tractor.

[7]Brought to permanent grade line. May do some graveling.

[8]Grading 33 miles.

[9]Grading only 25 miles.

[10]Blade grader; 100 miles county road, 150 miles township road; Tama County, 130 miles township; 10 miles permanent grading only. Webster County—Gravel, $50,000; may be raised for graveling through private subscription and federal aid. Grading only 50 miles.

Clayton County—50 miles of Blade grading only. Grundy County—We own our tractor grading outfit; expect to grade to natural grade some 50 miles; also grading only—12 miles to permanent grade, estimated at $10,000. Contract will be let in May or June. Adair County—50.000 cu. yds. of grading. Hardin County—200,000 cu. yds. grading only. Harrison County—We expect to be able to place to standard cross section and natural grade about 40 miles of earth road. There is no surfaced road in this county. Lyno County—Grading only with tractor, 60 miles. Marion County—About two miles and maintenance. Monona County—This does not include cutting to natural grade, standard section with blade grader. Grading only 5 miles. O'Brien County—Grading only, 15 miles of permanent grading. Iowa Highway, standard 15 miles temporary grade.

KANSAS.

ROAD CONSTRUCTION BY COUNTIES IN 1916.

Earth.

County.	Miles.	Surfaced Width, ft.	Av. Thickness Surfacing, ins.	Av. Cost per Mile Including Grading.
Atcheson ..	150	[1]30	..	$ 30.00
Dickinson	[2]100	30	..	25.00
Jackson ..	[3]136	..	..	30.00
Johnson ..	50	[4]16	..	.....
Nemaha ..	[2]20	..	..	.....
Riley	[2]100	30	..	.....
Shaunee ..	100	35	..	45.00
Sherman ..	235	20	6	55.00

[1] 26 to 30.
[2] Grading only.
[3] Of Cr. roads.
[4] Oil 16 ft.

Gravel.

County.	Miles.	Surfaced Width, ft.	Av. Thickness Surfacing, ins.	Av. Cost per Mile Including Grading.
Dickinson .	5	16	10	$2,500.00
Shaunee ..	6	16	10	2,500.00

[1] Also for Macadam.

Macadam.

County.	Miles.	Surfaced width, ft.	Av. thickness surfacing, ins.	Av. cost per mile, including grading.
[1]Atchison...	¾	16	8½	$6,800.00
Wyandotte .	3½	16	10	6,000.00

[1] Also gravel.

Bituminous.

County.	Miles.	Surfaced width, ft.	Av. Thickness Surfacing, ins.	Av. Cost per Mile Including grading.
Johnson ..	13	15	12	$16,000.00

Concrete.

County.	Miles.	Surfaced width, ft.	Av. Thickness Surfacing, ins.	Av. Cost per Mile Including grading.
Atchison .	2½	16	6½	$12,000.00

Brick.

County.	Miles.	Surfaced width, ft.	Av. Thickness Surfacing, ins.	Av. Cost per Mile Including grading.
Labette ...	1	..	..	....

AMOUNTS AVAILABLE IN 1916 AND PROBABLE AMOUNTS FOR 1917.

County.	Amount available in 1916.	Amount available in 1917.
Allen	?	?
Atchison	40,000	20,000
Dickinson	23,000	13,000
Greenwood	16,617	16,617
Jackson	18,000	21,000
Johnson	......	......
Labette	......	......
Miami	17,500	17,500
Nemaha	......	......
Ottawa	?	?
Riley	21,000	22,000
Shaunee	80,000	?
Sherman	13,000	15,000
Wyandotte	40,000	45,000

PROBABLE ROAD CONSTRUCTION BY COUNTIES FOR 1917.

County.	Earth miles.	Gravel miles.
Allen	...	...
Atchison	150	¾
Dickinson	[1]171	...
Jackson	44	...
Johnson	...	...
[2]Labette	...	...
Miami	...	...
Nemaha	[1]19	...
Ottawa	...	...
Riley	...	...
Shaunee	...	...
Sherman	200	...
[3]Wyandotte	...	...

[1] Grading only.
[2] Miles of concrete.
[3] Miles of macadam.

OREGON.

ROAD CONSTRUCTION BY COUNTIES IN 1916.

Earth.

County.	Miles.	Surfaced width, ft.	Av. cost per mile including grading.
Lane	25.05	..	$920
Multnomah ...	7½	24	....
Wallowa	10	12	400

Gravel.

County.	Miles.	Surfaced width, ft.	Av. thickness surfacing, ins.	Av. cost per mile including grading.
Lane	20.02	[1]12	8	$1,397
Multnomah	2	..	..	.....
Yamhill	135	..	..	......

[1]9-12 ft.

Macadam.

County.	Miles.	Surfaced width, ft.	Av. thickness surfacing, ins.	Av. cost per mile including grading.
Lane	2.35	12	8	$5,346
Multnomah ...	17	..	6	......
Yamhill	70	..	..	......

Bituminous.

County.	Miles.	Surfaced width, ft.	Av. thickness surfacing, ins.	Av. cost per mile including grading.
Multnomah ...	1¾	[1]18	6	......

[1]18 to 30 feet.

Concrete.

County.	Miles.	Surfaced width, ft.	Av. thickness surfacing, ins.	Av. cost per mile including grading.
Yamhill	[1]¼	..	..	......

[1]¼ mile built in 1916.

PROBABLE ROAD CONSTRUCTION BY COUNTIES FOR 1917.

County.	Earth, miles.	Gravel, miles.	Macadam, miles.
Coos[1]	40	..	..
Lane[2]	25	20	4
Multnomah	13	3	15
Wallowa	20	..	..
Yamhill[3]	12	..	15

[1]Grading only. [2]Crushed rock, 10 miles. [3]Concrete, 2½ miles.

AMOUNTS AVAILABLE IN 1916 AND PROBABLE AMOUNTS FOR 1917.

County.	Amount available in 1916.	Amount available in 1917.
Coos	....	400,000
Lane	158,609	175,000
Multnomah	690,460	525,997
Wallowa	35,000	37,000
Yamhill	....	....

WASHINGTON.

ROAD CONSTRUCTION BY COUNTIES IN 1916.

Earth.

County.	Miles.	Surfaced width, ft.	Av. cost per mile including grading.
Adams	38	..	$ 172
Douglas	6	..	2,000
Ferry	8	12	1,600
Garfield	10	..	2,800
Klickitat	70	16	600
Lincoln	40	..	200
Pend Oreille..	20	.	900
Snohomish ...	20	24	... ..
Whatcom	9	..	......

Gravel.

County.	Miles.	Surfaced width, ft.	Av. thickness surfacing, ins.	Av. cost per mile including grading.
Adams	9½	.	..	$5,100
Douglas	4	12	6	$5,500
Ferry	3	16	..	5,000
Garfield	3	12	7	5,000
Lincoln	25	12	8	2,500
Pend Oreille....	5	16	4½	2,500
Snohomish	30	22	5	6,000
Stevens	3.402	12	8	2,693
Whatcom	7	..	..	......

Macadam.

County.	Miles.	Surfaced width, ft.	Av. thickness surfacing, ins.	Av. cost per mile including grading.
Klickitat[1]	2	12	6	$8,000

[1]And grading.

Concrete.

County.	Miles.	Surfaced width, ft.	Av. thickness surfacing, ins.	Av. cost per mile including grading.
Pierce	16	..	5-7	......
Snohomish	45	16	5-7	$13,000
Whatcom	8½	..	..	......

PROBABLE ROAD CONSTRUCTION BY COUNTIES IN 1917.

County.	Earth, miles.	Gravel, miles.	Macadam, miles.	Concrete, miles.
Adams	45	12	..	..
Douglas	6	10	..	..
Ferry	[1]10	2	..	..
Garfield	4	1½	..	..
King	..	..	..	..
Klickitat	100	..	17	..
Lincoln	20	20	..	..
Pend Oreille	15	5	..	..
Snohomish	20	25	..	60
Stevens[2]	..	3	..	..
Whatcom	15	20	..	57½

[1]Also 20 miles grading only. [2]Crushed rock, probably 3 miles.

AMOUNTS AVAILABLE IN 1916 AND PROBABLE AMOUNTS FOR 1917.

County.	Amount available in 1916.	Amount available in 1917.
Adams	$107,000	$115,000
Douglas	35,000	55,000
Ferry	36,000	30,000
Garfield	60,000	20,000
King	$86,534.67	......
Klickitat	58,000	115,000
Lincoln	150,000	150,000
Pend Oreille	60,000	50,000
Pierce	179,000	175,000
Snohomish	1,250,000	1,250,000
Stevens	17,014.11	16,816.57
Whatcom	....	[1]800,000

[1]Including assessments.

PRESENT PREVAILING PRICES FOR MATERIAL AND LABOR FOR COUNTY ROAD CONSTRUCTION.

OHIO.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Allen	$2.10	$0.60-.95	$1.20	$1.25	$0.25-.35	$0.65
Butler	2.19	....	.75	....	.25	.60
Crawford	2.20	1.45	....	2.25	.30	*6.00
Cuyahoga	2.20	2.25	.20	1.70	.35-.40	.70
Fairfield	2.00	.65	.50	.65	.25	.55
Franklin	2.20	[1].70	1.00	[2]1.00	.35	.80
Hancock	2.00	1.00	....	1.40	*2.50	*5.00
Knox	....	1.55	....	....	.30	.50
Lorain	2.40	1.50	.	†2.00	*.20	.40
Mahoning	2.50	....	1.10	1.10	.35	.80
Muskingun	[4]2.19	†1.00	†1.00	.61	.25	.62½
Scioto	1.80	1.50	1.50	1.50	.25	.50
Summit	2.15	2.20	1.00	1.00	*3.00	.75
Wayne	2.19	1.50	1.00	.80	.20	.60

*Per day. Per ton [1]60c and 70c. [2]Washed crushed. [3]15 to 20. [4]Cloth.

INDIANA.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Clay	$2.19	$1.25	$0.85	$1.25	$0.20	$0.60
Delaware	....	....	1.00	1.00	.25	.50
Marion	1.80	1.25	.70	.50	.25	.50
Tippecanoe	2.16	.60	.75	.90	.25	.45

*Per day. †Per ton. [9]35 ct. to 75 ct. at pit. [10]At pit.

ILLINOIS.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Alexander	$1.60	$1.05	$1.10	$1.25	$0.20	$0.50
Bond	....	....	....	1.25	.20	.40
Brown	2.50	2.00	1.50	1.50	*2.00	*4.00
Christian	2.40	1.65	1.50	1.40	.25	....
Fulton	2.04	1.35	.75	.50	.25	.50
Grundy	1.75	1.10	.25	1.10	.30	.40
Henry	1.75	....	1.60	.90	.25	.50
Henry	1.75	1.00	1.50	1.25	*2.50	.50
Iroquois	2.20	1.20	1.25	1.25	.25	.55
Jasper	2.40	†1.15	1.15	1.15	.30	.35
Lake	1.70	1.35	1.00-1.35	1.25	.35-.40	.75
Lawrence	2.08	1.50	.90	.90	.20	.40
Lee	[9]2.10	1.00	*.50	.50	.30	.60
Logan	....	....	.12½	.10	.	...
McHenry	....	...	[1].10	...	.25	.60
McDonough	2.04	2.00	1.80	1.35	.22½	.40
Madison	2.08	1.45	....	1.35	.25	.50
Marion	2.00	1.30	1.50	1.15	.25	.50
Marshall	2.20	....	[5]1.10	[illegible]	.25	....
Menard	2.05	.	.	1.00	.20	.50
Montgomery	1.75	1.30	1.40	1.40	.25	.40
Peoria	1.85	[illegible]	[illegible]	†1.00	.25	.60
Pratt	1.68	2.00	1.80	1.80	.25	.50
Scott	1.60	....	[1].25	[illegible]	.20	.40
Stephenson	2.00	1.25	1.25	[illegible]	...	.50
Vermilion	2.07½	1.10	1.10	1.00	.30	.50
Vermilion	2.08	.95	1.15	.85	.25	.70
White	2.50	....	1.35	1.15	*2.00	[illegible]
Whiteside	[4]1.75	[illegible]	[illegible]	[5]1.60	[6].25	[7].60
Williamson	1.94	1.35	1.65	1.35	.30	.50
Winnbago	1.64	1.00	1.10	.90	.35	.70
Woodford	2.10	....	.60	.60	.30	.70

[1]25 ct. to 50 ct. [2]$1.75 to $2. [3]$0.90 to $1.70 [4]10 ct. to $1.60. [5]25 ct. to $1.60. [6]20 ct. to 25c. [7]40 ct. to 60 ct. [8]F. O B. cars. [9]$2.00 to $2.10 net.

MICHIGAN.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Berrian	$2.00	$1.40	$1.40	$1.00	*$2.50	*[illegible]
Calhoun	1.71	[1]2.00	[2]1.75	[illegible]	[illegible]	[illegible]
Crawford	[illegible]	[illegible]	1.10	[illegible]	[illegible]	[illegible]
Genesee	[illegible]	[illegible]	1.90	[illegible]	[illegible]	[illegible]
Jackson	[illegible]	[illegible]	[illegible]	.75	[illegible]	[illegible]
Kalamazoo	1.71	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Kalkaska	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lapeer	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Macomb	[illegible]	[illegible]	[illegible]	[illegible]	.30	[illegible]
Marquette	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mecosta	2.00	.	[illegible]	[illegible]	.20	.40
Missaukee	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.45
Montcalm	1.85	[illegible]	[illegible]	[illegible]	[illegible]	.40
Newoygo	2.10	[illegible]	[illegible]	[illegible]	[illegible]	.40
Ottawa	[illegible]	1.50	[illegible]	.	[illegible]	.45

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
St. Clair	1.72	1.70	[14]1.50	.80	*2.50	.55
Washtenaw	1.80	1.25	[6].10	[6].50	.30	.50

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*Per day. [1]$1.50 to $2.00. [2]$1.25 to $1.75. [3]25 ct. to 30 ct. [4]50 ct. to 60 ct. [5]$1.20 washed. [6]Pit. [7]50 ct. to 80c. [8]Gross. [9]Ton. [10]Baul sin. [11]Washed, ton. [11]25 ct. to 27½ ct. [12]15 ct. to 25 ct. [13]10 ct. to 15 ct. [14]10 ct. to $1.50.

WISCONSIN.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Adams	....	....	....	....	$0.20	$0.45
Barron	$2.25	....	....	....	.25	.50
Crawford	2.00	$1.50	$1.50	$0.20	.25	.50
Douglas	2.05	1.05	1.20	1.10	.25	†6.00
Eau Claire	....	2.00	.15	....	....	....
Fon du Lac	2.19	.87½	.60	.75	.35	.60
Forest	2.01	....	....	....	.25	.60
Green	.50	1.20	1.11½	....	....	....
Green Lake	2.10	1.70	1.00	.75	.25	.50
Iron	....	....	....	....	....	.60
Jefferson	....	.65	....	.50	.25	.50
Juneau	1.75	.75	.30	.25	.21½	.45
Kewanee	2.05	.70	[1].25	[2].25	[3].25	.45
La Crosse	....	1.10	....	....	.25	.50
La Fayette	1.59	.90	.55	.35	.25	.50
Milwaukee	2.08	....	[4].60	[4].54	.30	†7.00
Monroe	1.90	1.65	1.50	1.40	.25	.50
Ozaukee	2.20	.75	[5].75	.60	.30	.55
Price	2.20	....	....	....	.20	.45
Rock	1.19	.60	.10	.15	.25	.60
Sauk	2.00	1.00	.75	[6].95	.25	.50
Sawyer	....	....	....	....	....	.50
Trempealeau	2.00	1.75	1.50	1.00	[7].25	.50
Walworth	2.25	.65	.10	.25	.25	.60
Washburn	2.50	....	....	1.00	.25	.45
Waupaca	....	1.00	.25	....	†2.25	.50
Winnebego	2.30	.90	.25	1.00	.27½	.55

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†Per day. [1]15 ct. to 25 ct. [2]20 ct. to 25 ct. [3]20 ct. to 25 ct. [4]Washed pit. [5]25 ct. to 75 ct. [6]Washed and screened on track. [7]22½ ct. to 25 ct.

MINNESOTA.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Ailkin	$2.40	....	[1]$0.10	[2]$0.10	[3]$0.25	$0.50
Anoka	2.00	$1.00	.15	.20	.25	.45
Beltrami	2.15	2.20	[4]1.50	....	.22½	.50
Brown	....	....	.25	.25	.25	.45
Cass	....	....	.10	.10	.25	.50
Chippewa	.60	2.00	[5].35	[5].35	[6].60	.50
Chicago	1.50	1.40	.25	.15	.25	.60
Clearwater	2.40	....	....	....	[illegible]	.50
Cook	....	....	....	.10	.10	....
Cook	2.50	....	1.00	1.00	.27½	.60
Hubbard	2.60	....	....	....	.20	.40
Isanti	[illegible]	....	[1].15	....	.27½	.50
Itasca	2.00	2.25	1.50	1.00	.26	.55
Kandujohi	1.92	....	.21	.20	.25	.50
Jackson	2.50	....	.50	....	.35	.50
Loe Que Parla	....	1.50	.15	1.15	[7].25	[8].45
Le Suen	....	....	.25	....	.25	.50
Marshall	2.40	2.00	1.40	1.50	.25	.50
Meeker	2.00	....	[9]1.00	[10]2.00	.25	.45
Morrison	2.20	....	.15	.15	.25	.50
Murray	....	....	....	....	.27½	....
Norman	2.20	....	1.25	....	.30	.50
Polk	....	....	.30	....	.25	[11].40
Pope	....	....	.25	[12].25	.20	....
Ramsey	....	1.50	1.25	.25	*2.25	.45
Rack	2.20	1.25	[13].10	[14].50	.25	.45
Scott	2.00	....	[15].25	[1].25	[16].22½	[16].22½
Stevens	....	....	.35	.35	.30	.55
Todd	2.40	....	1.00	1.00	†2.25	†4.50
Waseca	2.10	1.50	....	1.40	.22½	.45
Washington	....	.90	.15	.20	.22½	.50
Winona	1.90	1.75	.45	.40	.25	.50

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*Per day. †Per ton. [1]At pit. [2]5 ct. to 10 ct. [3]25 ct. to 50 ct. [4]10 ct. to $1.50. [5]15 ct. to 35 ct. [6]25 ct. to 30 ct. [7]25 ct. to 27½ ct. [8]45 ct. to 50 ct. [9]60 ct. to $1. [10]$1 to $2. [11]40 ct. to 60 ct. [12]25 ct. to 40 ct. [13]Pit run. [14]Washed. [15]15 ct. to 25 ct. in pit. [16]20 ct. to 22½ ct.

IOWA.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Adair	$2.10	$2.10	$2.17	$1.86	$0.27½	$0.50
Buchanan	1.90	1.25	.25	.25	.25	.50
Buena Vista	2.20	....	.50	.50	.30	.55
Calhoun	2.60	....	1.40	1.40	*2.50	.55
Cerro Gordo	1.90	1.05	1.05	.45	*2.75	.50
Clayton	2.00	.25	[1].15	[1].15	*2.50	.50
Decatur	2.60	....	1.15	.90	.27½	.50
Dallas	1.93	....	[2].50	[2].50	.27½	.50
Floyd	2.00	....	[3].25	[3].25	.30	.50
Greene	2.25	....	.25	....	*2.75	.45
Grundy	[4].55	....	1.30	1.10	.30	.50
Hardin	2.20	[5]1.00	[5].25	.25	....	.50
Harrison	2.20	2.75	1.00	[6]1.00	.27½	.47½
Jefferson	[7]2.25	1.50	1.50	1.00	.27½	.50
Johnson	2.00	1.50	1.00	.60	[8].35	.50
Lyon	2.20	....	.50	.50	.30	.50
Madison	2.00	1.00	†1.20	....	[9].35	.55
Marion	1.93	....	1.50	1.10	.25	.50
Monroe	2.00	....	1.30	1.30	*2.50	*5.00
Montgomery	2.40	....	1.20	....	.27½	.50
O'Brien	2.08	....	.50	.50	.30	.50
Osceola	2.00	....	.50	.50	.30	.50
Palo Alto	6.20	....	.50	.50	.30	.50
Pottawattamie	....	....	....	....	.27½	.45
Sac	1.80	....	[10].75	[11].50	[12].30	[13].55
Scott	2.20	1.25	.90	.75	.27½	.60
Sioux	2.10	....	1.25	.75	*2.50	*5.50
Story	2.00	1.50	....	....	.25	.50
Tama	1.93	1.60	1.30	1.00	.30	....
Webster	....	....	....	....	[14].40	.50
Woodbury	2.01	....	.50	.50	.30	.70

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*Per day. †Per ton. [1]15 ct. to 25 ct. [2]50 ct. to $2.50. [3]25 ct. to 50 ct. [4]Retail per sack. [5]F. o. b. plant. [6]At pit. [7]Gross. [8]25 ct. to 35 ct. [9]30 ct. to 35 ct. [10]40 ct. to 75 ct. [11]30 ct. to 50 ct. [12]25 ct. to 30 ct. [13]50 ct. to 55 ct. [14]35 ct. to 40 ct.

MISSOURI.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Buchanan	$2.20	[1]$1.00	....	[2]$0.65	$0.20	$0.40
Butter	2.00	1.50	$1.50	1.00	.15	.30
Jackson	1.87	1.50	....	1.40	.25	.45
Marion	1.60	1.00	[3].10	[3].15	.20	.40
Randolph	2.40	2.00	....	1.65	.20	.45

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[1]Per ton f. o. b. quarry. [2]Ton. [3]Pit.

KANSAS.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Allen	....	....	....	....	$0.25	$0.40
Atchison	$2.00	$1.25	$0.80	$1.00	.30	.50
Dickinson	2.15	1.50	....	2.00	.30	*4.00
Greenwood	2.00	1.40	1.40	[2]1.60	.30	*4.00
Jackson	2.20	2.00	1.00	1.00	.20	.35
Johnson	2.00	1.75	....	1.75	.15	[3].50
Labitto	1.25	1.50	....	1.60	*2.60	*4.00
Miami	1.50	1.20	....	2.00	.25	.50
Ottawa	2.06	2.46	2.63	2.03	.30	.50
Riley	2.20	....	[4].75	[4].35	.25	.37½
Shaunee	2.00	1.35	[5].08	.25	.25	.50
Sherman	1.80	....	1.55	1.75	.30	.55
Wyandotte	1.60..	1.75	....	1.30	.25	.60

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*Per day. [1]25 ct. to 30 ct. [2]40 ct. to 50 ct. [3]Ton. [4]Washed, ton. [5]Pit, .06 ct. to .08 ct.

NORTH DAKOTA.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Foster	$3.40	....	$1.50	$1.50	$0.25	$0.50
McLean	2.55	....	1.25	1.25	.27½	.45
Renville	....	....	1.25	....	.35	.60
Stark	....	....	1.50	1.50	*2.50	*5.00

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*Per day.

NEBRASKA.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Adams	$3.00	†$2.70	$1.35	$1.35	*$3.00	*$4.50
Cheyenne	[2]2.50	....	.75	[3]1.00	.25	.40
Dawes	2.85	2.80	1.75	3.00	.30	.50
Gage	1.88	1.40	....	[4].90	.25	.50
Stanton	....	....	2.20	2.50	.25	*4.00
Thayer	2.50	....	....	....	.20	.40
Thomas	[1].80	7.00	....	....	.25	.50

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*Per day. †Per ton. [1]Cwt. [2]$2.40-$2.50. [3]75 ct.-$1.00. [4]85 ct.-90 ct.

ALABAMA.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Dallas	....	....	.90	....	.10	.40
Lamar	....	....	.31	.30	.12½	.35

KENTUCKY.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Adair		$0.38	....	....	....	....
Anderson	$0.06	1.00	....	$1.25	$0.15	$0.40
Perry	1.50	....	$0.75	[1].75	.20	.50
Russell	[2].75	1.55	.60	.50	.12½	.30
Spencer	....	1.70	....	....	....	....
Simpson	....	1.10	.25	....	*1.75	*3.50
Trumble	2.00	.85	.50	1.00	.15	.35
Woodford	2.25	1.25	....	1.30	.15	.35

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*Per day. [1]$0.50-0.75. [2]Cwt.

ARKANSAS.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Chicot	....	....	....	....	....	$0.40
Hempstead	$2.70	$3.70	$3.15	$2.25	*$1.00	.40
Sharp	2.70	....	....	....	.25	.30
Yell	....	....	....	....	.15	.40

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*Per day.

OKLAHOMA.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Beckham	$3.00	$1.30	$1.50	$1.50	$0.25	$0.37½
Caddo	3.20	3.00	....	....	[1].40	[2].50
Craig	2.40	1.50	1.50	1.50	.30	.45
Delaware	2.80	....	....	1.75	.20	.30
Garfield	2.23	2.50	....	[3].25	.25	.50
Grier	2.40	1.22	1.25	....	.25	.35
Major	2.50	2.00	....	1.25	.20	.35
Muskogee	2.20	1.75	1.25	1.25	.25	.50
Okfuskee	....	....	....	....	.15	.30
Payne	2.10	2.50	....	2.00	.25	.50
Wagoner	2.00	....	1.05	9.45	....	....
Woods	2.00	2.25	2.25	[4]3.50	.31¼	.50

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[1]$0.25-.40. [2]$0.45-.50. [3]Plus haul. [4]$0.50-3.50.

MONTANA.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Carbon	[1]$3.50	....	[2]$1.00	....	$0.30	$0.60
Dawson	4.00	....	....	....	.30	.60
Gallatin	2.60	[3]$1.50	1.75	$2.00	*3.00	*6.00
Hill	....	....	....	....	[4].40	.70
Musselshell	3.60	....	....	1.50	.40	*7.50

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*Per 8-hr. day. [1]$2.80-3.50. [2]00 to $1.00. [3]At quarry. [4]35-40.

COLORADO.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Dolores	....	....	....	....	$0.45	....
Fremont	$2.60	....	....	$0.25	.80	....
Lake	4.40	$2.00	$2.50	3.00	*3.00	*$1.00
Montrose	....	....	.30	.50	.32½	.62½

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*Per day.

NEVADA.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Clark	....	....	....	....	$0.37½	$0.75
Lander	....	....	....	....	*3.00	*6.00

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*Per day.

CALIFORNIA.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Colusa	$2.60	$2.60	$1.50	$1.50	$0.25	*$4.50
El Dorado	2.40	1.00	....	....	.31	62
Los Angeles	[1]1.75	[2].60	.30	[3].10	.25	.62½
Madera	3.50	.56	.40	.25	.25	.45
Riverside	1.34	.60	.30	.05	.25	.56
San Diego	....	1.25	....	1.00	.26	.63
San Joaquin	2.60	1.40	1.00	1.00	.35	*5.00
Stanislaus	2.51	†.90	†.90	†.80	.30	.50
Tulare	2.50	1.05	....	.50	.25	.50
Yolo	2.66	1.80	1.80	1.80	.25	.50

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*Per day. †Ton. [1]F. O. B. plant. [2]F. O. B. crusher. [3]Pit.

OREGON.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Coos	....	....	....	....	$0.40	$0.75
Lane	....	[1]$0.75	$0.03	$1.00	.25	.50
Multnomah	$1.90	1.00	.70	...	....	...
Wallowa	1.00	3.50	1.00	2.00	.30	.62½
Yamhill	2.20	.85	1.00	....	.25	.50

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[1]$0.50-.75. [2]In bunkers. [3]In cars.

WASHINGTON.

County.	Cement, per bbl.	Crushed stone, per cu. yd.	Gravel, per cu. yd.	Sand, per cu. yd.	Common labor, per hour.	Two-horse team and driver per hour.
Adams	$2.45	$1.00	$0.65	$0.65	$0.30	$0.60
Douglas	3.20	1.25	1.25	1.25	.35	.70
Ferry	....	....	....	....	.37½	.75
Garfield	3.00	1.50	2.00	2.36	[1].35	.60
King	2.19	[2]1.00	[3].75	1.00	.35	.75
Klickitat	3.50	1.00	[4]3.00	[5]3.00	.31	.62
Lincoln	2.50	....	....	....	.40	.70
Pend Oreille	2.60	.85	.50	.50	.32½	.75
Pierce	[6]1.89	....	....	....	.31¼	.62½
Snohomish	[7]1.75	2.00	1.00	1.00	.35	.75
Stevens	....	....	....	....	.35	.60
Whatcom	1.70	....	2.25	2.10	.30	....

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[1]$0.30-.35. [2]$0.75-1.00. [3]F. O. B. pit. [4]$1.00-3.00. [5]$1.00-3.00. [6]Net F. O. B. Tacoma. [7]F. O. B. station.

Waterworks and Hydraulic Issue
of

Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

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Volume XLVII. CHICAGO, ILL., APRIL 11, 1917. Number 15.

THE INCREASED PRICE OF WATER METERS AND ITS RELATIVE UNIMPORTANCE.

In 1914, and for three years prior thereto, the city of Boston paid $5 for ⅝-in. meters. On Jan. 9, 1917, the lowest bid for meters of this size was $8.40—an increase of 68 per cent. Accordingly the Boston Finance Commission not only recommended the rejection of all bids, but went so far as to say that:

> It is the consensus of opinion among engineers that the essential object to be gained by water meters in the city of Boston has already been secured. The more important services have been metered and the meters in future will be installed in suburban districts where the use of water is below the average. There is ample expert authority for the prediction that the daily consumption of water per capita in the city of Boston will not fall below 100 gal. per capita. The consumption for 1915 appears to have been 104 gal. per capita.

Furthermore, the Finance Commission hints at a possible collusion among meter manufacturers to raise prices now that 8 of the 10 meter makers are members of the Meter Manufacturers' Exchange. The Commission admits that it has no evidence of such collusion, but argues that "associations of this kind offer an excellent means for such collusion, and their existence is a potential danger to open competition."

The abnormally high prices of copper and other metals certainly go a long way toward explaining the rise in prices of water meters, and the high wages of skilled laborers go the rest of the distance to a full explanation. In view of these facts, the Boston Finance Commission need not look for any "collusion" to explain high prices of meters.

How far prices may recede after the war is problematical, but there is small likelihood of a great recession for years to come. In the manufacture of instruments of precision, such as water meters, labor constitutes so large a part of the cost that, unless wages fall to a very marked degree, no great decrease in prices may be looked for. There is but one way in which the low prices for meters that used to prevail will be had again, namely, as a result of meter manufacture on a large scale. This may come about in two ways: First, through the consolidation or merger of several meter companies. Second, through a general awakening of cities to the economic wisdom of metering practically every service.

We do not agree with the Boston Finance Commission that the "essential object to be gained by water meters in the city of Boston has already been secured." Evidently the Commission reasons that, having attained the "ideal" consumption of 100 gals. per capita per diem, Boston can do no better in the way of waste prevention. But even granting the truth of this very questionable assumption, there remains to be settled this pertinent question: Is Boston, including its suburbs, using all the water that can be profitably used to irrigate gardens?

Boston can probably add 50 per cent to its present water consumption with profit, provided the water is judiciously used for garden irrigation and for flushing streets. But before irrigation can be applied on the scale that is warranted, every service should be metered.

In every case known to us, where universal metering has been adopted, the per capita consumption of water has decreased not less than 25 per cent, and usually much more. The saving in coal alone, where water is pumped, richly repays the cost of metering. But remember that fuel ordinarily constitutes less than one-tenth the total annual per capita cost of supplying water, and that most the other costs are also affected to a great extent by the per capita consumption of water.

Quibbling about the cost of water meters is akin to haggling over the price of bait when a big run of fish is on.

On the one hand water is being wasted in vast quantities every day, while on the other hand there is need for more than is wasted to be used for garden irrigation. The few cents annual per capita cost of meters makes a sorry picture by contrast with the dollars of profit that metering can be made to yield.

WILL AMERICAN ARMIES SEE THE SOIL OF FRANCE?

The entrance of America into the world war has been foreseen a long time. Consequently "every house was in order" before the momentous second of April. This was well shown by the stability of the stock market, strikingly in contrast with the crash that occurred in August, 1914.

Many estimates of the duration of the war are being made. It seems to us that the German government has clearly indicated how much longer it is going to fight. If Germany had believed that the war would last till next December, it would scarcely have taken the action that has arrayed America among its enemies. The Germans know that American soldiers can not be trained and equipped for European battlefields short of nine months. They also know that once American weight begins to be felt in battle, the end will be very near. Hence it is certain that Germany counts either on starving England before next winter or on yielding to the ten nations whom she confronts.

The daily press is fond of likening Germany to a man who has run amuck, bereft of reason and governed only by rage. But the simile is poor. An individual may go crazy, a nation, never. Nor do sane men long submit to insane guidance; certainly not for a period of nearly three years of war. The German government, whatever its other defects, is not a government of lunatics. The idea that it could possibly bring England to her knees by wielding unmercifully the U-boat bludgeon was scouted by other nations. Only 60 days ago it was called the vision of an empire of fools. After two months of staggering losses of merchant tonnage, the idea of starving England looks far from fantastic. So, then, Germany "gone mad" is not so mad as most men had imagined.

It is a good rule in all competition, whether of industry or of war, to credit your adversary with a wit equal to your own. Certainly if one is attempting to fathom the motives of an adversary's act, it is foolish to start with the presumption that the act is begotten of pure pig-headedness or folly. Credit your adversary with a well reasoned motive, and you are likely to discover his postulates by reasoning backward from his acts.

A rational government at war with several hundred millions of people, does not invite another hundred million into the fracas without carefully pondering the consequences. Industrially considered, America out of the war is fully as damaging to Germany as America in the war.

America once fully in the war could furnish more men than England and France combined. Ergo, the war must be ended before America can possibly throw even a substantial part of her great weight of men into the battle line. To end the conflict victoriously for Germany but one possibility remains—the chance that rests with the flotilla of submarines.

The German people have been told by the German government that upon the success of this vast venture every hope is staked. But even had not a word been publicly whispered as to the motive of the act, the reasoning that has led to it would be plain to anyone who would put himself in the Kaiser's boots.

We shall begin the training of a million soldiers. We shall hear much of the progress of our preparedness program. But we shall never hear of an American regiment on the soil of France, for before the time of preparing the first levies has ended, ended also will be the world war. Nevertheless, it is the part of wisdom to train soldiers and enlarge our navy. We have long been derelict in the performance of this plain duty.

MAJ. CASSIUS E. GILLETTE AND THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

The death of Cassius E. Gillette, retired major of the corps of engineers, U. S. A., serves to revive memory of the great injustice that he suffered about ten years ago at the hands of a few members of the American Society of Civil Engineers.

Maj. Gillette applied for membership in that society and was blackballed by the friends of a member who had been a defendant in a suit brought by the city of Philadelphia to recover moneys paid for work that was alleged not to conform to specifications. Maj. Gillette, as chief of the Philadelphia Water Department, took an active part in the prosecution of the suit, believing that construction specifications had been violated by his predecessor. The court, however, exonerated his predecessor, and this exoneration was made the main argument for excluding Maj. Gillette from the American Society of Civil Engineers.

Some years before this a similar suit against Capt. Oberlin M. Carter and two government contractors had resulted in conviction, and it was universally admitted that the exposure of the crime, and subsequent successful prosecution of the case, was due primarily to Maj. Gillette's courage and resourcefulness. Prior to the conviction of Capt. Carter, Gillette, then a young subordinate officer, was socially ostracised in Savannah, and it is probably not overstating facts to say that three-fourths of the officers of the Corps of Engineers believed Capt. Carter to be innocent.

Bearing these facts in mind, and also remembering that improper construction had been discovered in the work of building the Philadelphia filtration plant, and that Maj. Gillette had been given a leave of absence from the corps of army engineers to "clean house" in Philadelphia, it is clear that he came to his new task determined to make a thorough job of the "house cleaning." This attitude of mind led him to make charges that could not be proved, but let it not be overlooked that he firmly believed that he was right even to the end of the trial. The editor met him not long ago on the train, and it was still evident that he honestly held to his old opinion as to the fact that those whom he had attacked were guilty.

Others, of whom the editor was one, believed that Maj. Gillette had erred in his judgment as to where the guilt lay; but those that knew him well never doubted his sincerity. Why, then, was he rejected as a member of the great national society of civil engineers? Many were the statements that Maj. Gillette was a "good man gone bad," "a man with a poisoned mind," and the like.

Forgetful of all his previous services to society in general, his one error of judgment was not only held against him as a bar to membership in this society of engineers, but was twisted into an unjust charge of moral turpitude.

And now the pity of it! Gillette is dead. A great engineering paper that lauded to the skies his courage, his character and his ability—shortly after the decision of the celebrated Carter case—gives him a 5-in. obituary notice, and utters not one word of rebuke to those who did him such grave injustice.

Maj. Gillette was a fighter by instinct, absolutely devoid of fear of consequences. He was an engineer of great versatility and acknowledged accomplishment. He was admired and loved by his close friends, who, in fact, far more bitterly resented his exclusion from the American Society of Civil Engineers than he did himself, much as that act pained him.

That great society is not a social club, yet there are always some members who seem to regard it as such, and make it difficult for their enemies to gain admission. Doubtless such members are well meaning, in most instances, and believe that any one who has "crossed their path" is a crook. But who is the better judge of any man's character, his friends or his adversaries? We take this occasion to urge upon every engineering society the wisdom of giving greater weight to the words of a man's life-long associates than to his occasional antagonists when testimony relates to the real fibre of his soul.

LET THE WATERWORKS SOCIETIES UNITE.

Commenting on our editorial suggesting the union of the American Water Works Association and the New England Water Works Association, the Water Works Journal says: "All in all, it would seem to be to the advantage of the entire industry if the unification were accomplished."

The Valve World, speaking of the suggested consolidation of the two associations, says: "There is no doubt that a union of the two associations would result in greater efficiency and in less cost, and the broader the basis of organization the better for all concerned."

Certain officers of the New England Association have spoken resentfully of the attempts of "outsiders" to effect a consolidation of these two societies. Now the "outsiders" can, in this case at least, plead no personal motive whatever. Looking at the matter wholly without bias, and seeking only the good of those in the waterworks field, we have urged the elimination of jealousies and the subordination of self interests, preliminary to serious consideration of bringing these two waterworks associations into some sort of union.

The annual convention of the American Water Works Association, to be held May 7-11, at Richmond, Va., offers another opportunity for expressions of opinion on this important matter. The letters that we have published show an overwhelming sentiment in favor of a union, and we doubt not that the majority of members in both associations would acclaim some sort of coalition, were they given a chance to vote on it.

To those officials who have alluded to this journal as an "outsider," we respectfully suggest that "insiders" are quite apt to grow attached to procedures that retard progress. Moreover, no association or society of technical men is quite justified in looking upon itself as if it were a family circle or even a club. If this narrow attitude is abandoned, it will be seen, we trust, that the editor of Engineering and Contracting can hardly be termed an "outsider" in matters that concern the whole waterworks profession.

THE HIGHEST EARTH DAM IN THE WORLD.

The Calveras earth dam, which is being built by the Spring Valley Water Co. to supply San Francisco and vicinity with water, is to have a height of 240 ft. above the bed rock on which it rests and will contain 3,100,000 cu. yd. of earth. It will therefore be the highest earth dam in the world.

This dam will impound 53 billion gallons, and will furnish a water supply of 30,000,000 gal. daily, from Calveras Creek, the site of the dam being 36 miles from San Francisco.

Nearly all the earth is pumped into place. The hydraulic processes of earth moving are those that were first developed in California, but they are being applied in this case on a more daring and grander scale than has hitherto been attempted. With a force of 60 men, working in two shifts of 30 men, an average of 3,600 cu. yd., has been hydraulicked and pumped into place every 24 hours for two years, the average distance of transportation being 3,000 ft. Each man, therefore, has averaged 60 cu. yd. per day, so that the labor cost alone has probably averaged about 5 cts. per cu. yd. But the cost of electric power for operating the pumps has evidently been quite a large item, for it is stated by Mr. T. A. Elliott, Engineer of the Spring Valley Water Co., that the direct operating cost of the first million cubic yards of earthwork was 25 cts. per cu. yd., exclusive of interest on the plant, superintendence, insurance, building roads, trails, camps, etc.

Practically all the material has been pumped into place, after first being hydraulicked from the hillsides into concrete lined sumps and thence lifted by pumps. A crew of 15 men is organized thus:

2 men on 2 monitors or giants,
1 man helping,
3 men on pumps,
2 men removing boulders from screens,
2 men moving discharge pipes,
1 electrician,
1 blacksmith,
3 general helpers.
—
15 men total.

The monitors, or hydraulic giants, are large nozzles (4 to 5 in.) that feed water against the earth banks that are to be washed down. Each monitor uses about 7 sec. ft. of water at 100 lb. pressure, and is furnished with water by a two-stage 10 in. pump driven by a 300 h. p. electric motor. The earth, which is about one-third clay and two-thirds sand and gravel, is "sluiced" or washed down open ditches, on a 5 to 8 per cent grade, to a concrete sump. There all boulders over 5 in. diameter are screened out. The mixture that reaches the sump is about 20 per cent solids and 80 per cent water. It is diluted to about 15 per cent solids, and then pumped into place through 14-in. slip joint, riveted steel pipes (No. 16 gage). To each end of each section of pipe is riveted a piece of No. 12 pipe 18 in. long; for this heavier tip stands up better under the battering that pipe receives when being jointed together.

As above stated, there are two monitors supplied with water by two pumps. Two more pumps (12 in.), each driven by a 300-h.p. motor, lift the material from sump into the dam; and as the dam increases in height booster pumps are added, so as to maintain a delivery of at least 10 sec. ft. in each pipe. The water that drains away from the earth deposited in the dam is conveyed back to the sump and used over again. The upstream slope of the dam is 3 to 1, and the downstream slope is 2½ to 1. A concrete slope wall is built on the upstream face. A considerable amount of earth is deposited from wagons, loaded by a steam shovel, on the down stream face, to hold the wet earth from sliding. The pressure of water on the upstream face serves the same purpose.

Most of the clay is deposited near the center of the dam, and the coarser material is deposited outside of the clay.

It is estimated that this great dam will be finished in 1918 at a total cost of about $2,500,000. The work is being done by company forces under the direction of Mr. Elliott.

HOW ENGINEERS CAN AID IN ELIMINATING TYPHOID.

Are you interested in eliminating typhoid from every American town and city? There are 300,000 typhoid cases every year, and nearly 7 per cent result fatally. Almost complete immunity from typhoid is securable by the treatment of water with liquid chlorine, and at a cost that is ridiculously low—so low that no sane business man would hesitate a second about the expense.

Are you interested as a citizen, if not as an engineer? If so write The Electro Bleaching Gas Co., 17 E. 41st St., New York City, for a booklet entitled "The Wise Cities Who Drink Safe Water." This booklet is a splendid example of educational advertising. It is full of data relating to 40 cities, giving costs of chlorination of water and resulting "profits" in health and life conserved.

Let every engineer, as well as every water works superintendent, do his part to spread such gospel as this booklet contains, and typhoid will soon be as rare as small-pox. It is our duty as technical men never to lose a chance to educate the public on sanitary matters, but we must first educate ourselves. Yes, we must do that and something more. We must put "pep" into our souls, the sort that drives us to action in behalf of humanity.

BACK YARD GARDENS AND WHAT THE WATER WORKS MANAGER CAN DO TO PROMOTE THEM.

It is stated by James H. Dix, superintendent of the Vacant Lot Cultivation Association of Philadelphia, that half the area of Philadelphia could profitably be used to raise garden truck. This would be true were the present waste of water eliminated by metering, and were the use of city water for irrigation encouraged by a sliding scale meter rate. But it is a mistake to urge everyone in a city to plant gardens, and then cut off the supply of water for irrigation.

Mr. Preston M. Conner, formerly editor of a farm journal, says:

> I have many friends who convert their back yards into miniature gardens annually. It has frequently been reported to me that money saved in this manner has been equivalent to rent for a month or two.

The abnormally high prices of garden truck make the present time unusually favorable for educational advertising regarding the use of water for garden irrigation. We suggest that water works managers will do well to enclose printed leaflets with the monthly water bills, encouraging the use of water for irrigation.

If the demand upon the pumping and piping system is apt to become too great, then divide the city into three irrigation districts, and assign two days a week to each district for garden irrigation. A similar practice prevails among irrigation companies in the West, and it can be applied in cities with equal success.

Let water works managers make up their minds to make city water plants of greater public usefulness, and ways will be found to overcome any objection to increased use of water. The new slogan may well be: Millions of gallons for use, but not one drop for waste.

EDITORIAL COMMENT.

The largest artificial reservoir in the world is that made in the valley of the Rio Grande by the Elephant Butte Dam in New Mexico. The dam, which was finished last October under the direction of the U. S. Reclamation Service, impounds 856,000,000,000 gal. or 2,267,000 acre-feet. It is built of cyclopean masonry, is 235 ft. thick at the base, 318 ft. high above the foundation, is 1,674 ft. long, and contains 611,000 cu. yd. The cost was about $5,000,000, or $2.20 per acre-foot. The impounded water forms a lake of 45 sq. miles, a shore line of 200 miles and an average depth of 65 ft. The water will irrigate 180,000 acres.

Mr. John Ericson has put the matter of meters very plainly to Chicago taxpayers. He warns them that if the present wasteful consumption of water continues, fully $800,000 will have to be spent annually during the next 30 years for new equipment that would not be needed if meters were adopted. But this does not include the doubled expense for fuel to pump the water with. Chicagoans are constantly complaining about the smoke that deluges the city from the stacks of railway locomotives, yet they say never a word about the volume of soot that their own city pumping stations discharge. Perhaps if the city council were required to go every week to Mr. John Ericson, the city engineer, and hand him, in ten dollar bills, the money to pay the coal dealers for the week's fuel, there would be an awakening in Chicago as to the present water waste, for under those conditions Mr. Ericson would be able to say every week: "Here, gentlemen, is $5,000 that you could have saved this week had the city been metered."

EFFECT OF ICE ON STREAM FLOW.

To the Editor: I note that in the March 14 issue of the Hydraulic number of "Engineering and Contracting," there is given space on page 246 to a letter by Mr. J. W. Ledoux, in which he criticises the methods of the U. S. Geological Survey, and infers that records of stream-flow published by the Survey are not corrected for ice during the winter months. As Mr. Ledoux in his article refers to your reprint of an article by Mr. Herschel from the Journal of the Boston Society of Civil Engineers, I will also refer you to the last issue of the Journal of the Boston Society of Civil Engineers, Vol. 4, No. 3, in which on page 123 you will find a discussion on the effect of ice on stream-flow during the winter months. These, or similar methods, have been followed by the Water Resources Branch of the U. S. Geological Survey for several years. C. H. Pierce,

Water Resources Branch, U. S. Geological Survey.

[The discussion referred to by Mr. Pierce follows.—Editor.]

Discussion of "Effect of Channel on Stream Flow."

Mr. Pierce—There is one phenomenon very closely related to the subject of Mr. Grover's paper which I believe has not been fully covered, and that is the effect of ice in destroying the stage-discharge relation which exists during the open-water period. A rating curve may be defined by a series of discharge measurements having a high degree of accuracy, but as soon as ice forms to any appreciable extent the channel conditions are changed and the rating curve is no longer applicable. In a section of the country where ice may exist from November to April, the minimum flow for the year possibly occurring during this period, the collection of winter records becomes a problem in itself. As in many other problems of hydraulics, the solution has been found by experiment and experience rather than from theoretical deduction.

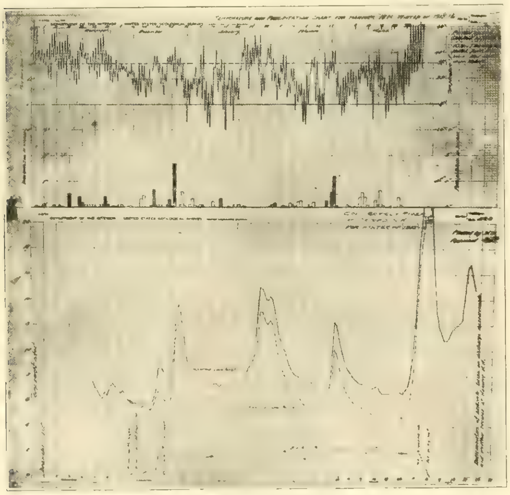

Fig. 1—Graphical Method of Determining Back-water from Ice.

It may readily be seen that the amount of backwater at the gage, that is, the increase in gage reading over what it would be under normal conditions, does not remain the same throughout the winter, but varies with the nature of the ice formation. In general, the backwater begins with the formation of shore ice or by ice freezing on exposed rocks at the control, although in some cases "anchor" ice and slush may be the first disturbing feature. There is often a sudden rise succeeded by a fall, after which the backwater gradually increases as the stream becomes covered with ice and as the ice increases in thickness. This may be explained by a decreased area in effective cross-section of the channel and by the formation of ice on the control. If the ice remains in place throughout the winter, with no break-ups or ice jam, it is possible with a few discharge measurements and a careful study of temperature and precipitation records to make a correction for the backwater and secure what may be called "effective gage heights," to which the open-water rating curve is applicable. This correction is best made graphically (Fig. 1) by plotting the results of discharge measurements and obtaining a backwater curve which is subtracted from the observed gage height graph to secure the effective gage height graph. In determining the backwater curve, the thermograph or temperature record and the precipitation are carefully studied to see that the results are consistent.

If the ice conditions do not remain stable throughout the winter, but are interrupted by break-ups and ice gorges, the work of making winter estimates becomes more complicated and a larger number of discharge measurements are needed.

One point should be emphasized in connection with this feature of the work, and that is, the selection of the site for the gage. If a site is selected with reference to its adaptability for winter work it may be possible to secure better results at less expense than would otherwise be the case.

A very full discussion of the effect of ice on stream flow may be found in Water-Supply Paper 337.

MAINTENANCE COSTS OF MOTOR-DRIVEN DEEP WELL PUMPS.

Operating costs of deep well pumps at the University of Illinois, Urbana, Ill., were outlined by Melvin L. Enger, Assistant Professor of Mechanics and Hydraulics, in a paper presented March 13 at the annual meeting of the Illinois section of the American Water Works Association. An abstract of the paper follows:

The water supply of the University of Illinois comes from five wells drilled about 140 ft. deep in the glacial drift of this region. The water-bearing stratum is about 15 ft. thick and consists of a sand containing much fine material. The water level in the wells when the pumps are not running is about 95 ft. below the surface and when the pumps are running about 110 ft. below the surface.

The water is pumped from the wells by means of motor-driven Luitwieler deep well pumps. The working barrels are 5¾ in. in diameter and the stroke is 15 in. The pump on well No. 2 is geared directly to its motor, the other pumps are belt connected.

The following table gives information concerning the wells and pumps:

	Well Number				
	1	2	3	4	5
Date drilled	1900	1907	1904	1905	1914
Depth, feet	138	140	142	140	*140
Diameter, inches	8	8	8	12	12
Cost of well, casing and screen	$559	$546	$699	$1348	$891
Cost, motor and pump	$375	$813	$788	$758	$810
Capacity, g. p. m., 1914 tests	60	69	81	71	75
Speed, r. p. m.	31	33	28	30	30

*About.

The cost of labor and material required to keep these wells in operation for a period of 16 months was as follows:

	Labor	Material
Well No. 1	$172.07	$100.26
Well No. 2	56.51	2.26
Well No 3	202.73	82.86
Well No. 4	113.05	42.93
Well No 5	147.28	88.08

During the period included the pumps were in operation as follows: No. 1, 44 per cent; No. 2, 34 per cent; No. 3, 70 per cent; No. 4, 86 per cent and No. 5, 89 per cent of the total time. Taking the average the wells were in operation 65 per cent of the total time, or 15.6 hours per day.

The pumps had been in use for periods ranging from 1 to 11 years, hence the results should represent the average performance of the pumps during their useful life fairly well. The principal cause of trouble is the fine sand getting into the well and into the pump. Rods, couplings, working barrel and packing are worn quite rapidly. The conditions under which the pumps work are decidedly poor, which accounts for the high cost of maintenance.

The total cost of maintenance for the five pumps during the 16 months was $1,008. This is equivalent to a cost of $151 per year for one pump operating 15.6 hours per day. Put in another way, it is equivalent to a maintenance charge of 0.82 ct. per 1,000 gal. pumped.

LOGIC FOR ENGINEERS.

IV. The Categories of Energy (Space and Time).

By Halbert P. Gillette.

[The previous articles of this series are: I—Energy and Cause-Effect (Jan 31). II—The Sense and Feelings (Feb. 28) III—The Categories of Energy (Mar. 28).]

Motion.—Motion may be defined as "a transition or passage from one point in space to another," but, as Locke pertinently inquires, "What is passage other than motion?" A nominal definition, like the one above, consists merely in indicating the significance of a word by the aid of a synonym. When nothing but such a nominal definition of a name can be framed, we may be certain that the name relates to something that defies analysis into parts or properties, and must be directly sensed to be really understood. In other words, it is one of the "ultimate realities."

Huxley says:

> All that we know about motion is that it is a name for certain changes in the relations of our visual, tactile and muscular sensations.

To this let us add a more detailed analysis of what happens when a motion is sensed. If the whole human body is "still" (that is, no sensation of muscular movement is perceived), and if recognizably different nerve elements in a series are excited in sequence, motion is sensed. A fly crawling across one's hand is felt to be moving; and a meteor shooting across the retina of the eye is seen to move. A man slowly turns his head to keep a moving object in view; then the motion is sensed through his "muscular sense," for the nerve-stuff chemically "reacts" to changes of muscular stress. Similarly a deer may perceive the motion of an invisible but sounding body, by funneling its ears upon the sound and moving its ears so as to maintain a maximum of sound intensity.

Motion, therefore, may be directly sensed in two ways: (1) By sensation of muscular movement, or (2) by sensation of successively stimulated retinal nerve elements that are instinctively known as being separate. In both cases, a sensation of motion arises from the excitation, successively of a series of nerve elements. In all cases the nerve plexus is the "datum," or reference base, of all sensed motion. Upon this nerve keyboard the fingers of energy may play an infinite variety of sequent sensations, and the perception of this sequence of excitation of different nerve elements is a perception of motion.

In the last article the "persistence of sensation" was discussed. It was shown that a sensation of continuity of motion occurs when each of a series of nerve elements is successively excited, the time interval being no greater than the duration of a single sensation. We are now prepared to understand the distinction between a sensation of motion and a sensation of change in general.

Change.—If a nerve element is excited and then ceases to be excited, or if it is quiescent and then becomes excited, there is a sensation of change. If a nerve element is now violently excited and now less violently excited, or vice versa, there is also a sensation of change. If serially successive nerve elements, a^1, a^2, a^3, a^4, etc., are successively excited there again is sensed a series of changes, but this kind of change is called a sensation of motion. If one nerve element is repeatedly excited, but at intervals of time less than the "duration of sensation," there is no sensation of change.

Change, it will be seen, always involves motion, but motion as such is never sensed unless there is excitation of each of a series of nerve elements in sequence. A succession of sounds of the same pitch and intensity, separated by intervals, produces a sensation of change; so also does any variation in pitch or intensity of a continuous note; but in neither case is there a sensation of motion.

Through every sense we perceive changes, but only through the senses of sight and touch (including tacticle, temperature and muscular senses) do we directly perceive what we call motion. Since time intervals may be "felt" through the actions of any of the senses, a sensation of passage of time is evidently not dependent on the sensation of motion.

Rest and Continuance.—When the same sensation persists we may call it persistence, but we commonly give persistence of sensation different names, depending on which of the five senses is kept active. When a uniform sound is heard, we speak of the sound as being continuous. But we do not commonly use the word continuous when a vision persists without changing. We then speak of the visualized objects as being at rest. Yet both the sound and the vision are persistent sensations. Rest is a term used in relation to sensations of sight and touch, whereas continuance is used in relation to sensations of sound, taste and odor.

It is quite important, I think, to note this distinction, not only because of its bearing upon a proper understanding of the meanings of such words as motion and rest, change and continuance, but because it elucidates the fact that we owe many distinctions between abstract terms entirely to our possession of different senses. Sight and touch are the only two senses that record space distinctions, as will be seen later.

Distance and Space.—I shall use these two words as synonymous, although the word space is often used to designate the "utter void" that is supposed to be thinkable apart from matter. I prefer "pure space" as a term to designate this "utter void," and to retain the word space in its oldest sense—a distance.

When a separately cognizable series of nerve elements, a^1, a^2, a^3, a^4, etc., is simultaneously excited, there is a sensation of extension—a sensation of a line. When only one cognizable nerve element is excited, there is sensation of a point. When two "separate" nerve elements, a^1 and a^4, are simultaneously excited, there is a sensation of two points spatially separated. When three or more separate points are thus sensed, there is perceived to be an equality or inequality of distance between pairs of points.

As I view it, the conception of distance as existing between two separate visible points, arises from the instinctively known existence of intermediate nerve elements capable of being excited. Thus, if the nerve elements a^1 and a^4 are excited, there is instinctive knowledge that intermediate nerve elements exist, and are excitable. This knowledge comes from inherited and personal excitation by "continuous" objects that cover the entire field of vision, also from experiences of motion of objects across the field of vision in every direction. A similar line of reasoning holds as to the tactile nerve plexus.

A sensation of distance is the invariable accompaniment of a persisting excitation of two or more nerve elements that are cognized instinctively as being separate nerve elements.

It happens that we do not cognize separate nerve elements in any of the five senses except those of sight and touch, including the "muscular sense" and "temperature sense" as species of the sense of touch. That distance or space is not perceived by the senses of taste or smell, is evident, but it is not so evident that the sense of hearing is equally incapable of sensing distance unaided by any other sense. A faint sound, it is true, usually indicates remoteness of the sounding body; but that the remoteness is inferred and not directly sensed may easily be proved. The tricks of ventriloquism show how easily the "ear is deceived" as to distances and sources of sound. So, too, a drummer readily conveys the impression that his drum is receding or approaching the hearer, merely by varying the intensity of the sound. When a man or an animal locates, by listening, the direction from which a sound comes, the act of location is invariably accomplished by muscular motions. Even then, there is a tacit assumption that the muscular motion changes the position of the head or the ear more rapidly than the position of the sounding body is changed. Hence that species of touch called the "muscular sense" is relied upon to aid the ear in determining spatial difference.

Since nerve "elements" of hearing, tasting and smelling are not cognized as separate elements of the nerve plexus, space is not sensed by the senses, hearing, taste and smell. For the same reason, therefore, motion is not sensed by these three senses.

Anticipating, for a moment, the discussion in the next article, the sense of touch senses mass as well as space. The eye, however, does not sense mass as such, but does sense distance. Indeed the eye is pre-eminently the space sensing organ.

"Space," says Sir John Herschel, "in its ultimate analysis is nothing but an assemblage of distances and directions." It is difficult to improve upon this definition, if there is objection to the use of distance as a synonym for space. But whatever definition is given either for space or distance, the definition is purely nominal, and merely explains one word with others that mean the same thing. Space, then, is an ultimate conception that defies analysis; but being a conception, a sense-record, it relates to energy and has no meaning apart from energy.

"Pure Space."—Metaphysical attempts to frame a conception of space as an entity apart from matter have led to endless confusion with consequent endless dispute. When the word space is used to denote "pure space," or "empty space," all that it can mean is complete void or absence of energy of every kind. "Pure black" is the absence of all color; "pure space" is not only the absence of all color, but of all other forms of energy. Hence "pure space" can produce no sensations. In the absence of sense-records there can be no reasoning, so that it is impossible really to reason about "pure space" and its "properties." All "reasoning" of this character is mere juggling with words. As examples of this pseudo-reasoning, I will quote from Kant's "Critique of Pure Reason":

> If we take away by degrees from our conceptions of a body all that can be referred to mere sensuous experience—color, hardness or softness, even impenetrability—the body will then vanish; but the space which it occupied still remains, and this it is utterly impossible to annihilate in thought.

If this sort of reasoning is sound, then the following non-sense is equally sound: If we take away by degrees every shade of color and light from several objects that completely fill the field of vision, until naught remains but perfect blackness, then all visible things will vanish; but the pure residuum of their color will still remain, for it is utterly impossible to annihilate this pure residuum in thought.

Kant goes on to say:

> We never can imagine or make a representation to ourselves of the non-existence of space, though we may easily enough think that no objects are found in it.

Attempt yourself to do what Kant says "may easily" be done: Try to imagine a space containing no objects. One may imagine an "empty room" as an "empty space," but is this imagining or re-presenting no objects whatsoever? Not a bit of it, for the six walls of the room are objects. And so it is with every attempt to conceive a portion of "pure space" apart from all matter, an attempt that necessarily brings in matter to confine the space. Conceiving space in a room is like "feeling the holes" in a flute; what is felt is the wooden edges of the flute holes.

Locke, although not often given to futile expressions, does make statements about "pure space" that are meaningless. For example:

> The parts of pure space are inseparable one from the other; so that the continuity cannot be separated, neither really nor mentally. * * * The parts of pure space are immovable, which follows from their inseparability. * * * Thus the determined idea of simple [pure] space distinguishes it plainly and sufficiently from body, since its parts are inseparable, immovable, and without resistance to the motion of body.

All of which is perfectly futile talk. The absence of any physical property—call the absence whatever name you please—is different from the presence of any physical property. Yet by no stretch of imagination can a difference of this sort—between absence and presence—be made to serve as a reason for speaking of an absence as if it had the properties of a presence.

Time.—The ideas of "change" and "time" are closely akin. Time is sensed as a series of changes, and when time is denoted with precision it is through a precise numbering of changes that are uniform. No great precision in determining the uniformity of successive changes is possible unless the changes are motions of a rhythmic or cyclic character. These, in brief, are the conclusions that I have reached after long reading and longer reflection about the category Time. It may be well to contrast these conclusions with some others.

Locke has said that "duration is the idea of perishing distance," but this is only a figure of speech. He gives a more definite statement thus:

> It is evident to anyone who will but observe what passes in his own mind, that there is a train of ideas which constantly succeed one another in his understanding as long as he is awake. Reflection on these appearances of several ideas one after another in our minds, is that which furnishes us with the idea of succession; and the distance between any parts of that succession, or between the appearance of any two ideas in our minds, is what we call duration [or the passing of time].

Note his introduction of the word "distance" in his explanation of time. Yet, in another part of his "Essay on the Human Understanding" he says:

> It is not motion, but the constant train of ideas in our minds, whilst we are waking, that furnishes us with the idea of duration * * * and therefore we should as well have the idea of duration [time], were there no sense of motion at all.

But, one may well ask, how can there be a "train of ideas" without motion, and how can Locke consistently speak of a "distance" between parts of a "succession" of ideas, each of which lacks a definite position? The trouble that he brings upon himself is the one that nearly every philosopher has courted by attempting to describe time in terms of space or motion. Herbert Spencer, in his Psychology, makes the same futile attempt. After speaking of the "impossibility of considering either Space or Time alone," he says:

> Time in general, as known to us, is the abstract of all relations of positions among successive states of consciousness.

Note that Spencer differs little from Locke in the wording of this definition of time, and even less in the significance than in the wording of the thought, for both he and Locke introduce the concept of Space in defining Time. Spencer proceeds to trace what he believes to have been the evolution of the conception of Time, starting with "two successive tactual sensations" as involving the germinal idea of Time."

Kant, in his "Critique of Pure Reason," discusses Space and Time in language that is often difficult to understand, partly because he fails to define many of the terms, but largely, I think, because the terms are really indefinable; that is, they do not stand as symbols for any definite sense-record. Nevertheless, his acute mind often flashes an illuminating expression, thus:

> Time has to do neither with shape nor position; on the contrary, it determines the relation of representations in our internal state. And precisely because this internal intuition presents to us no shape or form, we endeavor to supply this want by analogies, and represent the course of time by a line progressing to infinity, the content of which constitutes a series which is only of one dimension; and we conclude from the properties of this line as to all the properties of time, with this single exception, that the parts of a line are coexistent, while those of time are successive.

Here Kant avoids the error that Locke before him, and Spencer after him, fell into, of introducing the concept of "position" in discussing what time is. But he falls into quite as grave an error in speaking of the "properties" of time, as if time were a particular substance or energy-group. Yet he contradicts his own statement later when he says:

> Time is not something which subsists of itself, for if it were it would be something real, yet without presenting to any power of perception of any real object. * * * Time is nothing else than the form of the internal sense, that is, of the intuitions of self and of our internal state. * * * Time is therefore merely a subjective condition of our (human) intuition, and in itself, independently of the mind or subject, is nothing.

This sort of "train of thought" soon jumps the track of reality and mires deep in the bog of metaphysics. If time is purely subjective, was there no lapse of time prior to sensient life? If not what is the meaning of our geological calculations that this globe was millions of years old before life began?

Leibnitz, prior to Kant, regarded time as "the confused apprehension of a system of relations." Had he gone several steps farther, he might have come measurably close to an answer; for it seems to me that a vague conception of time is an apprehension of a considerable—but not definitely known—number of changes. Whence it follows that a definite conception of time is an apprehension of a precise number of changes of a standard kind.

Through the power of memory we are able to recall the distinction between a large number of changes and a small number of similar changes. Thus, I can recall that between the day of the first remembered event in life and yesterday, there were vastly more sunsets than there were since I was last ill, although I can not recall even the approximate number of sunsets during either period. Similarly one may close his eyes, and by feeling the beats of the pulse, but without counting them, roughly estimate differences in the lapse of time. Thus, while a song is being sung (say 5 minutes), a half a glass of water may be swallowed (say 15 seconds), and the beating of the pulse may be felt throughout these events. There can not be the slightest hesitancy in pronouncing the duration of the song as being far longer than the duration of drinking the water, although there is difficulty in stating their relative durations. Now if the number of pulse-beats be counted in both cases, quite an accurate statement can be given as to the relative duration of the song and the drinking.

This illustrates the difference between vague perceptions of the duration of events and more precise perceptions of the duration. In both cases the perception consists in remembering either vaguely or precisely, the numbers of certain serial changes of the same kind. Locke was right in stating that the passage of time is perceivable even in the absence of any perceived motion, but he failed to observe that it is the remembered enumeration (vague or precise) of changes that gives us cognizance of the lapse of time. Spencer likewise fails to recognize the part that remembered enumeration of changes plays in the evolution of a conception of time, and he makes the error of trying to derive the conception of time entirely from a perception of motions, instead of deriving it from perceptions of changes of all kinds.

Time is "sensed" through sense-records made by every one of the five senses, hence the perception of time is not limited to sensations of motion. Nevertheless, only rhythmic or cyclic motions furnish precisely determinable units of time. Rythmic sounds may seem to recur at equal intervals, but the ear furnishes no means of recording sound effects so that they can be accurately compared. Distances, however, may be accurately compared. Hence if there is any recurrent motion whose duration is proportional to a distance, that motion may become a precise unit of time. The pendulum is such a unit.

"Pure Time."—Metaphysicians attempt to frame conceptions of time apart from matter. They try to regard time as a purely "subjective" phenomenon. When they think they have succeeded in the effort, they call their pseudo-conception "pure time," but its sole claim to "purity" lies in the fact that it is literally pure nonsense. It is no more possible to reason about time apart from energy than it is to reason about space apart from energy. "Pure time," like "pure space," is only a negative term, implying the entire absence of any energy-group, and therefore in itself beyond the province of reason.

In the next article the fourth category, Mass, will be discussed, and a summary given of the four categories of energy.

METHODS AND COST OF METER READING AT TERRE HAUTE, IND.

Contributed by Jay A. Craven, Assistant Manager The Terre Haute Water Works Co.

Following the installation of a large number of meters, about 3,700, early in the year of 1916, when the metered customers were more than doubled, being increased from about 3,200 to 6,900, it became necessary to rearrange the meter reading books. At first this was done by two or three of the men best acquainted with the city, the loose leaf meter cards being placed in binders which were not numbered at this time.

It might be of interest to show here one of the cards. These cards have space for two years' readings. The reverse side of the card gives the instruction to the readers, with index numbers referring to conditions usually met with when reading. These numbers are used by the readers when the situations they cover are encountered. Time is thus saved and the condition of the books bettered because the reader is not required to write them in detail.

As the extra work in the office, due to installing the meters, such as changes in the ledgers, etc., decreased, more attention was paid to getting the meter cards into the books in better routes, and more evenly divided as to territory covered, than could be made from memory. To this end, a large map of the city was obtained, scale 250 ft. to the inch, and upon it were placed symbols to indicate the location of the meter; 0 indicating meter at the curb and B in the basement.

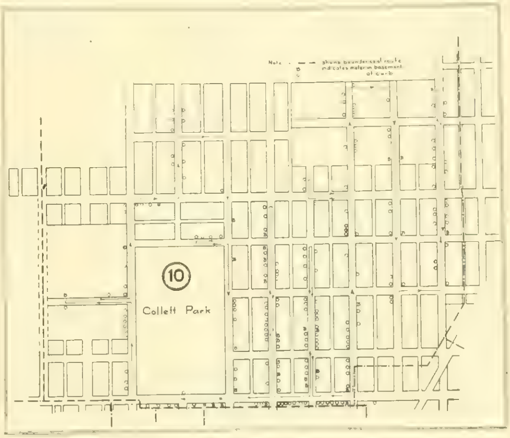

Fig. 1—Section of Large Routing Map, Showing Typical Route.

Figure 1 is a section of the large routing map showing a typical route, No. 10. The boundaries covered are indicated by the dash and dotted line and the route covered by the reader by the light line, the arrows indicating the direction he travels. In an outlying section such as this, the installation of new meters may mean some changes in routing, but as the direction lines are in pencil, this can easily be done. The actual routing was done from the large map which was almost indispensable for this purpose.

An endeavor was made to get approximately 200 cards in each book and as nearly as possible this was adhered to, but they vary from 100 to 250 cards each, in many instances it being impossible to arrange them otherwise. The consumers' ledgers are arranged by streets, beginning with the north and south streets at the river and going east and then the east and west streets, beginning at the north end of the city. An ideal routing of the reading books would have followed the ledgers, but this was out of the question.

As in most places, meters are more or less scattered in the outskirts, it was thought best to arrange two bicycle routes, one for the north end and one for the south end. The entire city was laid out in routes. This map is used as an index to the meter books and is kept at the counter on the first floor, the large scale map being kept on the second floor for lack of wall space on the first. It is well adapted to its purpose of finding in which book the cards are when it is necessary to refer to them in checking back customers' accounts, etc.

Books 1 to 17 inclusive cover the north end of the city. In the western, central and southern parts of the city, it has been possible to follow the ledgers fairly closely, as the greater part of the customers are on the north and south streets, there being very few in the odd ledgers on the cross streets. Typical of these routes are Nos. 3, 7, 24 and 25. In the northern part, there are more on the cross streets, the majority still being on the north and south streets. In the east end, the majority are on the east and west streets, with but a few on the north and south streets. This has principally influenced the odd shapes of the reading sections. While both the bookkeeper and the readers were considered in the routing, preference was given to the latter, as he had lots of ground to cover, while the former was inconvenienced only in the handling of the books.

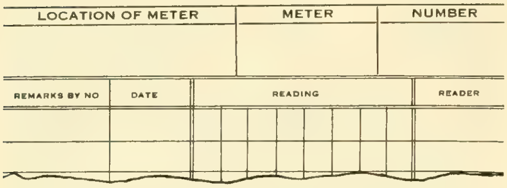

Fig. 2—Loose Leaf Meter Card. Actual size 4¼ In. x 9 In.

Although the first routing from the large map was a great improvement over the memory routing, quite a few changes were made after the first two or three readings. The readers would indicate on a sheet of paper attached, where the book could be bettered, where owing to the service being taken off of a side street, the cards were out of order, etc. At the present time, no complaints are heard from the readers.

Meter reading usually begins about the 22d of each month. Previous to this time, cards for all new meters have been inserted in their proper places, notation having been made on the cards where meters have been removed, etc. Also all electric reading lamps have been tested out and made ready the previous night.

Blackboards have been prepared upon which the numbers of the books have been placed, together with columns for the names of the readers and their time out and in. The books are taken in order of their numbers, the reader then registering on the blackboard. There are about 10 readers on the average, made up of men from the pumping station, the office and the regular inspectors.

The name of the reader, with the time on each book, is copied during the reading period into a more permanent record, to which is later added the total number of meters in each book, the number read and number not read, the average read per hour and the record of weather conditions each day, this being an important factor. Totals at the bottom also show the total number of hours for reading, total meters read and not read and the average number of meters read per hour per man. In addition to this record, other figures obtained later are the total number of meters read by each man, his average per hour, and the total cost of reading. All the above figures mentioned are based on the reading of the books. The total cost covers the first reading, also second trips where meters could not be read the first time, and re-reads where readings were in question.

While this record has been kept only since last September, it has proved very stimulating to the readers in endeavoring to do as well or better than the preceding readers on the route, and as the time, together with the numbers read and not read (the latter being due almost entirely to people not being at home) are kept, it has not tended toward developing speed at the risk of careless reading.

A few tables giving the results might be of interest, as comparison can be made with others and mutual benefit derived. I have heard of 75 meters an hour being read and this kept up for 10 hours a day; I frankly acknowledge that I don't see how it is done, unless conditions are altogether more favorable than here. When a man reads an average of 40 meters an hour for the total time he is out, he is covering some ground, about one-third of the meters being in basements, and time is necessarily lost in getting at them.

Table I shows the information copied from the blackboard; that is, the number of the book, the time required to read it and the weather condition, the reader's name being omitted here, however, as of no consequence at this time. Also the information obtained later by one of the clerks, the number read, the number not read, and the average number read per hour is added.

An interesting point to call attention to here is the high average per hour on books 4, 13, 19, 23 and 28, made by one of the best readers. The records made have only been bettered on one book and in one month, by the man setting the pace for the February reading.

To indicate how time varies on the same books for different readers, these five books for the six-month period, September, 1916, to February, 1917, will be shown in Table II.

Weather conditions are a very important factor, as can be readily seen in the above table in the record made by

TABLE I.

Book.	Time, hrs.	Number Read.	Number Not read.	Average per hr.	Weather.
1	12.00	152	6	13	Oct. 23 and 24 clear and cool, fine reading weather.
2	9.25	188	5	20	
3	9.25	227	11	25	
4	4.25	224	5	53*	
5	5.75	200	5	35	
6	7.50	216	12	29	Oct. 25 cloudy, no rain; colder. Good reading weather.
7	7.75	201	5	26	
8	9.00	201	17	22	
9	8.00	216	7	27	
10	7.25	204	8	28	Oct. 28 clear. Fine reading weather.
11	3.50	120	3	34	
12	7.50	221	11	29	
13	5.00	229	5	46*	
14	11.00	242	9	22	
15	7.00	210	6	30	
16	11.00	224	10	20	
17	4.50	151	7	34	
18	8.25	192	3	23	
19	4.75	158	8	33*	
20	7.00	95	4	14	
21	10.25	193	11	19	
22	6.25	108	1	17	
23	4.00	215	7	54*	
24	4.50	224	10	50	
25	7.75	199	4	26	
26	6.75	218	4	32	
27	8.00	222	6	28	
28	4.50	220	3	49*	
29	4.75	218	6	46	
30	8.50	182	10	21	
31	10.00	216	3	22	
32	7.25	216	5	30	
33	6.50	217	8	33	
34	7.75	198	8	26	
35	8.00	88	2	11	
Totals	254.25	6,805	235	27	

*Indicate same reader.

TABLE II.—A COMPARISON OF METERS READ IN FIVE BOOKS FOR THE SIX MONTH PERIOD.

	Average Number of Meters Read per Hour.					
	1916				1917	
Book No.	September.	October.	November.	December.	January.	February.
1	27	53*	29	25	21*	25
13	28	46*	26*	14	21	34*
19	15	33*	22*	16*	22	16*
23	17	54*	22	31	23	23
28	38	49*	45	20	51	44

*Made by the same reader.

TABLE III.—A SUMMARY OF METER READING RECORDS.

Month.	Total hrs.	Number meters read.	Per hr.	Weather.
Sept.	288.25	6,617	23	Fine, bright and cool.
Oct.	254.25	6,805	27	Fine.
Nov.	243.00	6,676	27	Bad -rainy.
Dec.*	347.10	6,703	19	Very bad; cold and deep snow.
Jan.	291.45	6,672	23	Fair, but cold.
Feb.	243.60	6,660	27	Fair, warm but muddy.

*Time shown only represents the time the book was out, and on most of the books, a man accompanied the reader to sweep the snow and assist in locating the meters. The cost for this month was exceptionally large.

the same man. October was exceptionally good for reading, while with the exception of one or two days in the four following months, conditions were bad.

A summary of the total time for the first reading of the meters, second trips not considered, is given in Table III.

Table IV is shown to give an idea of the wide variations due to the readers as well as to weather conditions. As regards the latter, the best record was made in October when the weather was most favorable. It will also give others a basis of comparison as to the number read per hour. If a comparison is made, however, it must be borne in mind that about one-third of the meters are set in the basement. The weather conditions should also be noted.

The cost per meter includes the reading of the meters missed the first trip, also the rereading of meters where the first was in question. The average paid the readers is 25 ct. per hour.

It is believed that the keeping of time and other data on individual books has been of material benefit. Formerly, a general summary was made of each reader's total record, but the individual record as regards each book was not kept. Some of the older records were made by a few of the readers getting the same books each month, these being the ones where meters were not so scattered and where the reading should be done more quickly. With a blackboard this is overcome, although there was a tendency at first to take the easy reading books out of numerical order. Now the records set are on merit and the readers who formerly were unfortunate in getting the scattered meter books have an equal chance. Each month the names of the readers making the five best records are placed on a blackboard, together with the average number of meters read per hour.

The small index map has proven very satisfactory for locating the proper book for a section of the city and the large on has also proven very adaptable to getting new cards in their proper locations in the books.

TABLE IV—SHOWING FIVE FIRST RECORDS MADE IN THE SIX-MONTH PERIOD.

	Average per hour					
	1916				1917	
Rank.	September.	October.	November.	December.	January.	February.
1	36	46	37	*	34	43
2	34	43	36	..	27	37
3	25	34	31	..	26	28
4	25	30	29	..	23	24
5	24	29	28	..	22	23
Av. of five	29	36	32	..	26	31

*No average for December because of weather conditions requiring two men to a book, one to shovel snow, etc.

TABLE V—COST OF READING.

	Meters		Cost per meter in cents.
Month.	Read.	Not read.	
Sept.	6,617	297	1.7
Oct.	6,808	235	1.1
Nov.	6,677	220	1.1
Dec.	6,703	258	3.7*
Jan.	6,672	235	1.6
Feb.	6,680	289	1.3

*In December, extra men to shovel snow, etc.

Average Cost of Laying Water Mains in the District of Columbia.—The following table from the report of J. S. Garland, Superintendent Water Department, shows the average cost per foot for laying water mains for the year ended June 30, 1916:

Character of pavement cut.	Size of pipe.	Cost labor per lin. ft.	Cost for material, cuts to pavements, etc., per lin. ft.	Total cost per lin. ft. laid.
Sheet asphalt	3	$0.872	$0.515	$1.387
Sheet asphalt	4	.595	.808	1.403
Macadam	4	.482	[illegible]	1.704
Cement	6	.616	.933	1.549
Sheet asphalt	8	.565	1.281	1.846
Macadam	8	.424	.846	1.270
Unimproved	8	.352	.809	1.161
Macadam	12	.461	1.228	1.689
Unimproved	12	.352	1.147	1.499
Sheet asphalt	16	.868	2.668	3.536

The excessive cost of 3 and 4-in. main was due to pipe being laid in short sections in alleys and house connections.

METHODS FOR REMOVING AQUATIC VEGETATION FROM IRRIGATION CANALS.

Excellent results in removing moss from the irrigation canals of the Salt River Project of the U. S. Reclamation Service have been obtained with an Acme harrow, according to an article by A. J. Haltom, Irrigation Manager, in the April Reclamation Record. On this project it was necessary to devise some method whereby the moss could be eliminated without turning water from the canals.

The Acme harrow, or, as called by some, the orchard cultivator, is a machine consisting of long parallel blades attached to an iron frame, with the blades turned to enter the ground and cut the roots horizontally an inch or two beneath the surface. It slices off the top surface of the silt, and after the moss roots are thus cut the moss floats to the top and is then caught by men stationed below on bridges or checks. This machine is drawn by means of a chain to a team on each bank of the canal, and by adjusting the length of the chains the harrow can be run on either slope or in the bottom of the canal. In this manner the moss can be removed without interrupting the flow of water. On part of the canals it was necessary to keep men and teams at work until the end of the season, and on others an occasional cleaning every two or three weeks answered all requirements. The Acme is also useful in stirring up the silt in the bottom of the canal, causing it to be again picked up in suspension, with the result that the silt deposits are considerably decreased. The stirring of the silt with the resultant muddy water tends to retard the growth of the moss farther down the canal, and it also helps to puddle leaky portions of the canal.

The methods employed on the Minidoka Project for the control of moss, weeds and willows in irrigation canals also were described in the above mentioned issue of the Reclamation Record, from which we quote as follows:

It became necessary to begin the work of removing the moss as early as June 20. At this time the only method which was found successful in clearing the moss from the larger canals was by cutting with the Ziemsen submarine saw. This saw consists of a flexible band of steel with hooked teeth on both edges. It can be obtained in any length, and the weights to hold it to the bottom are adjusted to fit the canal. It is operated at an angle of about 30° with the cross-section of the canal, the crew always working upstream. The rate of progress is from 6 to 12 in. at each double stroke and from ¼ to 1 mile per day can be cut with each saw. The long streamers of moss when cut rise to the surface and float down to the next bridge or check, where they are thrown out by men with pitchforks. At times it has been necessary to have as many as three men to pitch out the moss cut by one crew.

Last season it was necessary to go over many of the canals three times. During the middle of the season the moss grew very rapidly. In one canal a length of 2½ ft. was measured 3 days after cutting. In another place a length of 8 ft. was observed 14 days after cutting. After the 20th of August the trouble began to decrease, partly due, no doubt, to the shorter days and less sunlight, partly to cooler weather, and partly to a slackening demand for water.

Removing the moss by dragging a ½ or ¾ in. chain by teams on each bank was not successful until after about the middle of August, when the moss had ripened enough to break away at the first joint. Prior to that time the chain would drag over the moss without breaking it. A V made out of railroad iron and weighing in all about 600 lb. was dragged up the canal but this method was not successful, as the rails slipped over the moss.

In laterals of about 1 ft. depth it was found that a spring-tooth harrow could be used quite well, but it had to be taken out and cleaned about every 50 ft. The harrow was not successful in the larger canals. In laterals the water was lowered at times so that there was only enough to support the moss and men were put in with brush scythes. This method was found very useful where the farmers on some lateral were having serious trouble in getting water and would get together to co-operate in cleaning it.

Where it can be done, the cheapest and most effective method of cleaning the canal is to shut the water out entirely and let the ditch dry in the sun. Five to seven days' exposure is necessary ordinarily to kill the moss. This method kills the growth, but does not destroy the bulb. On the Minidoka project it has not seemer practical to adopt this method, as it is felt that continuous water service was more important to the farmers than the money saving which would have resulted from a method such as this.

During the 1916 season, 260 miles of cleaning were done. The total cost of this work was $4,200, making the cost per mile a fraction over $16. The average cost per mile of the different methods is about as follows: Sawing, $22; chaining late in the season, $8; cutting with scythes in laterals, $11; spring-tooth harrow in laterals, $9.

Weeds and grass growing along the inner slopes of the canal and laterals decrease the discharge to a considerable extent by retarding the velocity. These are removed by men with brush scythes at a cost of about $12 per mile.

Willows are cut by men with grubbing hoes and brush scythes. Men equipped with grubbing hoes go ahead for cutting out larger willows, and men with scythes follow and cut the remainder. In the past little attention has been given to willows on the Minidoka project, but it is now believed to be advisable to cut them annually. The clearing during the last season was done with the idea of keeping stumps down so that a mowing machine can be used to cut the new growth. The cost on the removing of willows has been about $27 per mile. About 23 miles of banks were cut over.

THE ECONOMY OF METERS.

Over 99 per cent of the water services of Elgin, Ill., are metered. The advantages of the arrangement are set forth briefly and convincingly in a paper presented at the recent meeting of the Illinois Section of the American Water Works Association by Mr. C. L. Kohn, Commissioner of Public Health and Safety, from which we quote as follows:

The City of Elgin commenced installing meters in 1902. At the end of the year there were 3,263 consumers and of these 210 were metered. The pumpage for the year was 725,000,000 gal., the revenue being $30,013.68.

In 1910 the City had 4,655 consumers, of which 2,728 were metered, the pumpage for the year being 787,000,000 gal. and the revenue $53,687.63.

In 1915 the City had 5,226 consumers, of which 5,200 were metered, practically 99 per cent. For various reasons 26 consumers could not be metered.

The pumpage for this year was 413,360,580 gal., the revenue $54,223.88, showing an increase in revenue of 14,210.20 over the year 1902, and a decrease of 311,639,-20 gal. in pumpage, notwithstanding the fact that the umber of consumers in 1902 was 3,263 as against 5,226 1915, or a difference of 1,963 consumers.

Cost of Installing Meters at Detroit, Mich.—The average st of installing meters by the Board of Water Commisners of Detroit, Mich., for the year ending June 30, 1916, is shown in the accompanying tabulation. The figures include the cost of the meter:

Size.	Number	Cost	Average labor and cartage	Average material.	Average cost
	[illegible]	$ [illegible]			
[illegible] inch	[illegible]	[illegible]	$0.23	$ 4.49	$ 4.72
	2,069	6.50			
[illegible] inch	[illegible]	7.30	.23	6.96	7.19
	706	9.30			
1 inch	51	[illegible]	[illegible]	9.29	9.58
1½ inch	[illegible]	21.00	1.40	21.00	22.40
[illegible]	47	[illegible]			
2 inch	[illegible]	[illegible]	1.40	34.11	35.5[illegible]
[illegible] inch	21			60.00	60.00
4 inch	11			120.00	120.00
[illegible] inch	[illegible]			250.00	250.00

Set by consumer

A METHOD OF FINANCING SANITARY IMPROVEMENTS FOR THE POORER PROPERTY OWNERS.

An interesting plan for financing sanitary improvements without throwing too great a burden on the owner of the property was outlined by R. A. Butler of the Jenne & Butler Co., Indianapolis, Ind., in a paper presented at the recent convention of the Indiana Sanitary & Water Supply Association. An abstract of the paper follows:

In every community in Indiana there are hundreds of citizens who would thoroughly appreciate the advantages of sanitary closets, but who are still tolerating open vaults on their premises. Bath tubs are luxuries they forego, not through lack of desire, but through necessity. These people by no means constitute all those who are living in unclean surroundings, but they form a class so large that their conversion to sanitary living would be a step toward community health that would almost solve the problem of the sanitary engineer and reduce his opposition to a comparatively negligible quantity.

Progress has been made in other fields that should be applied in the sanitary field. Distributors of luxury have evolved methods of co-ordinating the financial problem with their merchandise. Sellers of service have found ways by which the poorer purchaser could be accommodated as well as the rich, comforts have been brought within the reach of the small pocketbook as well as the large.

Today you may buy an automobile on a partial payment plan that brings its luxury in reach of the moderately well-to-do. You may enjoy the benefits of electric lights and power, and pay for your equipment while you enjoy it. Gas is brought into your kitchen and a range sold to you on terms that you can meet out of a very small income. But you cannot have a sanitary toilet in your home until you have scraped together the cash with which to satisfy the plumber, the sewer digger and the water company.

Analyses of the ownership of property that is not modern reveals a condition contrary to the popular view. Small properties that lack modern sanitary equipment are not held by grasping big business men. They are either owned by those who are struggling to make investments at the ratio of rent, or by the moderately well-to-do who have invested their all in one rental speculation, and have not the additional capital with which to improve their holdings.

These people are good credit risks. They have shown their thrift in the purchase of their properties and they are able to qualify by the moral standard that financiers now say they consider most thoroughly in making loans. Yet no one has gone into the business of making it easy for them to care for their health. No one has offered to them the advantages now offered to the man of moderate means who would own a touring car. The opportunities of financing modern sanitary necessities have long been neglected.

Electric light companies are wiring homes for electricity and extending the cost over a reasonable period. Gas companies are installing ranges on payments. They have the sales and the collection systems already in operation, and the addition of appliance accounts is simple and involves little cost. The manager of the People's Gas Co. of Chicago recently asserted that the greater agency of development in the gas manufacturer's field today was the partial payment plan of selling appliances. His company has more than 600,000 of these partial payment accounts on its books.

This same method of financing can and will be applied to water service and modern sanitary improvements in the near future. It is a problem that confronts water companies all over the country and it is a solution that means more services on their mains, the use of more water and the improvement of the health of whole communities.

Whether or not water companies or municipally owned water works systems embark in the plumbing business directly or indirectly is a matter of small moment, and local conditions.

The water utility that undertakes plumbing as a side issue for the purpose of intensifying its patronage will encounter difficulties in the way of criticism. It may be denounced as a grasping corporation seeking to establish a trust in the plumbing business. But the fact remains that because of its buying power, its credit and the ability to wait for its profit and take it in increased water consumption, it will be able to give to the property owner more satisfactory plumbing at less cost than it can now be obtained.

But even for the water utility that is restricted as to business by its charter or its ownership, there is no great difficulty in the partial payment plan. The automobile distributor has pointed out the way and the way is easy to adapt.

For example, in Indianapolis there is an outlet from the mains of the water company for every 7.5 persons in the city. The average size of a family is five. It follows that the business of the water company is 33⅓ per cent less than it might be. This one-third represents the field of prospects and any merchandising expert will say that one-third of the whole of a city's population is a desirable field to cultivate.

With one-third the city as the field, there is necessary to the development of business, capital sufficient to equip the possible user of water for its enjoyment. The installation desired in the class of homes in the city that now have no water service, has been estimated at a physical cost of from $100 to $250, according to size and location. Taking the lowest figures as a basis, interest at 6 per cent for two years and a brokerage charge of 6 per cent could be added and the installation made at a partial payment cost of $4.92 a month for 24 months. To this should be added the cost of water, not exceeding $1 a month, making in all a charge against the property of $5.92 a month, or approximately 19.7 ct. a day.

This should prove a fairly attractive proposition for the man with a small property whose concern is a safe water supply such as is furnished by water utilities. Other advantages, such as baths and toilets, will follow quickly on the heels of the first installations and their costs will be relatively small.

Brokerage charges should be no greater for the large installation than the small, if based on cost, but policy might dictate a sliding scale in order that first costs of installation be reduced.

The organization of a funding company with capacity to handle this business should not be difficult. Capital would, of course, demand an ample margin of security, but it is the opinion of legal authorities that this security could easily be provided.

Two methods have been suggested for the protection of the capital necessary to make a home sanitary. Indiana laws provide for a lien against property so improved to protect the capitalist who makes the improvement. The process, however, is not without its troublesome delays and risks, and, unfortunately, it is possible for more than one lien to be filed against a property, thus making it necessary at times for the satisfaction of all liens, in order to satisfy one.

A more applicable plan is the leasing of such fixtures as enter into the house to be improved. The cost of the fixtures in a modern home is not the major item of expense, but the fixtures are the necessary item to the enjoyment of sanitation. It is urged by plumbers and others that no property owner who has once had plumbing fixtures installed can afford to have them removed from a house. The removal is attended by such wreckage that the property would depreciate in value to a point far in excess of the cost of the fixtures and the labor necessary to sanitary plumbing. It is argued that an owner who has profited by better rentals or greater conveniences would exhaust every resource rather than suffer the removal of plumbing fixtures which have only recently been installed. Consequently, those who have investigated the credit problem maintain that a lease drawn to cover the fixtures installed in the house and affording legal right to enter and remove these fixtures in event of non-compliance with the terms of these leases would in practically all instances be sufficient protection for capital, no matter how timid it might be.

It is also argued that the funding company would deal only with that class of persons who have demonstrated their thriftiness and integrity in the acquisition of property, and the moral risk would be of the highest class. However, it is to be presumed that some lessees would fail in performance and then, with a proper lease, the funding company would be in a position to take a lien for the labor done, or to remove the fixtures if it were deemed advisable.

Organization and operation of the funding company is possible at a very small overhead cost. The amount of capital actually necessary is dependent on the size of the field, but a consideration not to be overlooked is the fact that each month brings part of the capital back for reinvestment, and with each monthly payment the individual account becomes more secure.

Operating expenses of the funding company would consist of three branches, promotion of business, investigation of risks, and collection. The expenditure necessary for the promotion of business will depend on the method of operation finally adopted.

Investigation shows that the great cost involved in installations such as are under consideration is not the plumbing, but the sanitary sewer, the very thing that sanitation demands.

This cost is not one of material, but of labor, and probably no one plumber has any advantage over another in doing it.

Plumbing is largely a matter of labor and in most communities is so restricted by ordinance that it must be made standard. Fixtures furnish the greatest opportunity for cost reduction by purchase in bulk, but there are other advantages to be considered in determining whether a funding company should work in conjunction with all local plumbers or take over plumbing as a part of its business.

In the automobile business it has been found more desirable to have the funding company separate from the sales agency, in name at least. Perhaps this would be more advisable in sanitary funding. Certain it is that if the funding company were holding out to each plumber an opportunity to do work and collect his money immediately, even though the employer is not in a position to pay him cash, every plumber in the community would become an enthusiastic salesman and the cost of sales would be greatly reduced for the funding company.

The ideal situation seems to involve the organization of a company with sufficient capital or financial backing to be able to say to the property owner, "Hire any plumber you choose and select any fixtures you desire. We will pay the entire cost and give you two years in which to pay us."

Then, with the plumbers of a city the enthusiastic boosters of the funding company, the examination of the risks is the next important operating detail. It has been estimated that this work can be accomplished at a minimum fee of $5 a risk. The burden of showing title to the property is to be thrown on the applicant for a contract, and extensive investigation is not necessary. A manager of ordinary intelligence would be capable of judging the advisability of the contract and a single inspection of the property should be sufficient to satisfy him. The time element is not important and his work could be so distributed as to make it least expensive.

For convenience of collection the water rental and the partial payment should be payable at the same place, the lessee being billed for the total and the utility holding the funding company responsible for the water rental. A simple card system of bookkeeping and a stenographer supplied with suitable letter forms for prodding the delinquents should accomplish the collections without great expense.

Whenever it is possible for the small property owner to improve his property without shouldering a hardship in the form of a big initial expenditure, it will be easier to insist on sanitary improvements. The greatest argument against the condemnation of open vaults and unsafe wells will disappear. Laws designed to wipe out these breeders of disease will not be assailable on the grounds that they are confiscatory.

Property owners will benefit by increased value of their holdings. Renters will find properties more desirable. Water utilities will cut down their fixed charges as they increase the number of their patrons. Improved sanitation will bring about better health and there will be far more individual effort toward community health.

THE USE AND COST OF CHEMICALS FOR WATER TREATMENT.

Recent experiences of a number of purification plants, most of which are located in the middle west, in the use and costs of chemicals required for the treatment of water supplies were given in a report of the committee on Water Purification of the Indiana Sanitary and Water Supply Association. The report, an abstract of which follows, was submitted at the recent meeting of the association by Mr. Philip Burgess, Consulting Engineer, the chairman of the committee.

Information is shown in Tables I to V relative to the uses and past costs of filter alum, sulfate of iron, hydrated or quick lime, hypochlorite of lime, and liquid chlorine.

One of the interesting features brought out in the tables is with reference to the quantities of chemicals required and the cost of treatment of a water supply with hypochlorite of lime and liquid chlorine. As shown in the table, the average quantity of hypochlorite actually applied during 1916 was 9.0 lb. per million gallons. The average quantity of liquid chlorine used was 2.3 lb. per million gallons. The average cost of the hypochlorite during the past year has been 6.9 ct. per pound and of the liquid chlorine 15.8 ct. per pound. It is of course true that the larger plants have been able to purchase these materials at lower prices than the smaller plants. The ratio of cost of treatment, using either of the two materials, therefore is determined in part by the size of the plant. During 1916, however, the average ratio of costs shown in the table was such that the cost of the liquid chlorine treatment was about 0.6 of the cost of the hypochlorite treatment. Moreover, the ease of obtaining a proper application of the liquid chlorine has and will increase the favor in which this material now stands. This is due, of course, to the development of simple and accurate machines which permit a uniform application of the liquod chlorine in any quantity desired.

TABLE III—PLANTS USING HYDRATED OR QUICK LIME.

Name of town.	Population. thousands	Water consumption, 1,000 gal. daily.	Lbs used per million gal during 1916. Max	Min.	Ave.	Cost per ton during 1916. Max	Min.	Ave.
New Albany, Ind.	21	2,065	86	53	67	.....	.....	$8.50
Evansville, Ind.	76	9,000	333	70	...	$8.20	$6.30	6.50
Columbus, Ind.	9	1,530	...	...	157	.....	.....	8.00
Bedford, Ind.	10	1,500	...	..	148	.....	.....	7.60
Indianapolis, Ind.	272	19,943	273	191	...	.....	.....	8.50
E. St. Louis, Ill.	76	18,600	545	29	140	16.00	6.40	10.00
Kankakee, Ill.	14	2,041	424	46	187	....	.....	8.05
New Orleans, La.	375	28,600	1,328	385	777	.....	.....	4.45
St. Louis, Mo.	755	99,386	1,302	373	752	4.285	3.65	4.00
Cincinnati, O.	286	54,000	185	59	96	6.00	5.12	5.33
Sharon, Pa.	29	3,290	...	...	225	9.44	5.65	7.50

*Quick lime.

TABLE IV—PLANTS USING SULPHATE OF IRON.

Name of town.	Population. thousands	Water consumption. 1,000 gal. daily.	Lbs used per million gal. during 1916. Max.	Min.	Ave.	Cost per ton during 1916. Max.	Min.	Ave.
New Albany, Ind.	21	2,065	122	74	93	$24.00	$24.00	$24.00
Evansville, Ind.	76	9,000	833	111	370	17.20	10.00	10.00
Bedford, Ind.	10	1,500	...	. .	222	21.00	11.00	.....
Seymour, Ind.	6	650	...	.	..	... .	.....	22.94
Indianapolis, Ind.	272	19 943	230	136	. .	.....	.....	13.58
Kankakee, Ill	14	2,041	356	18	138	..	.....	*22.40
St. Louis, Mo.	755	99,386	194	0	..	12.00	10.00	10.00
New Orleans, La.	376	28,600	178	2	64	.....	...	14.00
Cincinnati, O.*	286	54,000	570	93	185	12.00	10.60	19.66
Sharon, Pa.	29	3,290	...	.	279	21.00	11.00	16.00

*Price of sulphate of iron during 1917 is $18.26 per ton delivered in new 100-lb. sacks.

TABLE I—PLANTS USING ALUM AS COAGULANT

Name of town.	Population.	Water consumption, gal. daily.	Lbs. used per million gal. during 1916. Max.	Min.	Ave.	Cost per ton—During 1915—Max.	Min.	Ave.	During 1916—Max.	Min.	Ave.
Seymour, Ind.	6,500	650,000	429	38	166	$22.00	$19.50	$20.75	$38.00	......	.....
Logansport, Ind.	21,000	5,500,000	727	110	.	22.00	......	......	26.00	$22.00	$24.00
Terre Haute, Ind.	71,000	5,116,000	738	130	299	17.00	17.00	17.00	24.20	24.20	21.20
Valparaiso, Ind.	7,500	818,800	245	166	205	24.80	17.80	18.97	71.20	24.80	48.00
Paoli, Ind.	1,500	150,000	713	356	534	16.00	16.00	16.00	35.00	35.00	35.00
Anderson, Ind.	22,000	1,794,000	1,111	...	253	19.00	19.00	19.00	24.00	24.00	24.00
Indianapolis, Ind.	272,500	19,943,000	775	47		......	... .	......	......	......	16.66
Cairo, Ill.	17,000	4,310,000	800	120	411	.....	.... .	. ....	21.10	18.80	......
		528,000	1,810	28	173	......	......	......	65.00	32.00	60.00
Decatur, Ill.	38,500	4,800,000	400	60	195	......	......	......	......	......	22.00
East St. Louis, Ill.	76,000	18,600,000	615	63	187	......	......	......	18.00	16.60	17.20
Kankakee, Ill.	14,500	2,041,000	401	3	79	......	......	......	......	......	21.60
Evanston, Ill.	28,500	6,840,000	107	86	96	......	......	......	26.80	17.80	25.60
Moline, Ill.	29,000	3,700,000	1,344	150	372	......	......	. ....	......	......	21.40
Mt. Carmel, Ill.	9,000	1,000,000	400	100	250	......	......	......	65.00	19.00	25.00
Pontiac, Ill.	8,000	606,000	1,071	71	262	......	......	......	61.00	41.00	56.60
Streator, Ill.	14,500	2,250,000	700	150	220	......	......	......	......	......	.....
Quincy, Ill.	37,600	1,600,000	1,071	377	170	......	......	......	......	......	24.96
Rock Island, Ill.	28,000	2,200,000	715	..	261	......	......	......	......	.....	20.00
St. Louis, Mo.	755,000	99,386,000	375	.	99	......	......	......	21.00	16.80	17.28
Youngstown, O.	100,000	11,700,000	. . .	.	313	......	......	......	......	......	24.75
Columbus, O.	215,000	19,800,000	... .	.	243	......	......	*7.27	......	......	*20.08
Pomeroy and Middleport, O.	8,500	450,000	150	50	85	.... .	.... ..	30.00	80.00	55.00	60.00
Harrisburg, Pa.	73,000	8,626,600	... .	.	95	......	......	......	......	.....	60.00
Sharon, Pa.	29,000	3,290,000	350	175	240	......	... .	19.00	55.00	25.00	50.00

*Cost of materials only.

TABLE II—PLANTS USING HYPOCHLORITE OF LIME

Name of town.	Population.	Water consumption, gal. daily	Lbs. used per million gal. during 1916 Max.	Min.	Ave.	Cost per ton (cents)—During 1915—Max.	Min.	Ave.	During 1916—Max.	Min.	Ave.
Seymour, Ind.	6,500	650,000	10	6	.	3.0	2.0	....	20.0	9.0	....
Logansport, Ind.	21,000	5,500,000	25	10	. . .	5.0	1.0	. . .	5.0	1.9	. . .
Columbus, Ind.	9,500	1,530,000	....	.....	4	....	....	....	.....	.....	6.5
Valparaiso, Ind.	7,500	810,500	....	.....	9	3.05	2.5	2.54	....	.....	4.25
Bedford, Ind.	10,500	1,500,000	..	.	9.2	....	....	....	6.75	6.75	6.75
Terre Haute, Ind.	71,000	5,116,000	14.1	3.5	8.0	....	....	1.6	.....	.....	4.5
Evansville, Ind.	76,000	9,000,000	11.1	5	..	....	....	....	4.25	1.40	1.69
Anderson, Ind.	21,500	1,790,000	.	.	6.6	....	....	1.75	.....	.....	4.0
New Albany, Ind.	21,000	2,065,000	25	15	20	2.0	1.5	1.75	12.0	7.0	8.0
		328,000	70	6.4	27	...	....	....	11.0	7.0	10.0
Decatur, Ill.	38,500	4,800,000	8.5	4.1	6.4	...	....	....	7.7	1.9	4.0
Evanston, Ill.	28,000	6,840,000	4.1	2.99	3	...	....	....	13.0	4.5	7.2
Kankakee, Ill.	14,500	2,041,000	5.5	3.2	4.3	...	....	....	.....	.....	16.0
Pontiac, Ill.	8,000	606,000	22	10	15	...	....	....	8.0	4.0	5.3
Moline, Ill.	29,000	3,700,000	19.9	.. .	13.0	...	....	....	.....	.....	17.5
Mt. Carmel, Ill.	9,000	1,000,000	6.0	2.0	3.0	...	....	....	12.0	2.5	5.0
Waukegan, Ill.	20,000	4,318,000	..	.	10.0	...	....	....	11.0	4.0	6.0
New Orleans, La.	376,000	28,600,000	7.0	1.6	4.3	...	....	....	12.4	10.0	6.5
Columbus, O.	215,000	19,800,000	5	5	5	...	....	1.34	....	.....	4.15
Harrisburg, Pa.	73,000	8,626,600	..	. .	6.7	...	....	....	.....	.....	7.0
Sharon, Pa.	29,000	2,290,000	10	7	8	6.5	1.7	...	15.0	.....	. . .

Much could be said also relative to the use and cost of filter alum as a coagulant. Possibly the most striking feature of the table is the great increase in the cost of this material caused by the present European war. In some instances the operators of plants have foreseen the increase in price and have been able to secure contracts for periods of three or four years at prices very much less than the prevailing market prices. In other cases, however, the operators have had to pay market prices which in some instances have been over three times as great as the market prices which prevailed two years ago.

Partly on account of the high cost of alum there has been a considerable increase in the use of sulfate of iron as a coagulant. In a general way it would seem that the cost of sulfate of iron has been determined by the price which the market would stand. Prices paid have ranged from $10 to $24 per ton.

TABLE V PLANTS USING LIQUID CHLORINE.

Name of town.	Population, thousands.	Water consumption, 1,000 gal. daily.	Lbs used per million gal. during 1916. Max.	Min.	Ave.	Cost per pound during 1916 (cents). Max.	Min	Ave.
Logansport, Ind.	21	5,500	3.0	1.5	...	..	...	17.5
Michigan City, Ind.	22	6,000	2.0	1.5	1.8	15	...	.....
Valparaiso, Ind.	7	818	2.4	1.3	1.9	21	...	....
New Albany, Ind.	21	2,065	2.5	1.2	1.6	25	8	19
Indianapolis, Ind.	272	19,943	2.2	0.9	1.6	...	..	12.5
Cairo, Ill.	17	4,310	4.0	2.25	3.0	...	...	20.0
		328	3.3	0.7	1.3	...	...	20.00
Kankakee, Ill.	14	2,041	4.1	2.7	3.6	...	...	19.5
Moline, Ill.	29	3,700	7.5	2.8	4.0	. .	..	10.5
Rock Island, Ill.	29	3,200	. .	...	3.5	...	..	18.00
Quincy, Ill.	37	1,600	4.5	1.8	3.5	...	...	17.0
E. St. Louis Ill	76	18,600	5.5	2.0	2.0	...	..	11.0
St Louis, Mo.	755	99,386	4.8	0	1.66	13.625	8.0	9.06
East Chicago	29	6,678	3.0	1.5	2.5	..	...	11
Cincinnati, O.	386	54,000	1.4	0.9	1.1	17.5	17.5	17.5
Sharon, Pa	29	3,290	2.5	1.8	2.1	18	18	18

It is of interest to note that there has been less fluctuation in the cost of lime than in the cost of any other chemical required for water purification purposes. During 1916 these costs have ranged from $5.65 to $9.44 per ton for hydrated lime. Moreover, the average yearly costs per ton have varied only from $6.50 to $8.50 during 1916.

Meter Reading at Elgin, Ill.—For the reading of water meters, the city of Elgin is divided into three districts, meters in each district being read every quarter. The results are most satisfactory and economical to the department for the following reasons: A certain amount of revenue is received monthly with which to do business, enabling the department to take advantage of discounts in the purchase of material and supplies. The office force is materially reduced as well as the number of meter readers. The readers of meters alternate, in no case reading the same meter two consecutive quarters, thus avoiding carlessness and errors.

Rates for Supply of Water for Building Purposes.—The following schedule of rates is in force at Johnstown, N. Y., for water used for construction purposes:

Plastering, per 100 yd.	25 ct
Brick, per 1,000	4 ct.
Stone, per cu. yd.	2 ct.

The supply must be specially applied for, and permission obtained from City Clerk for each separate building, job or piece of work, and paid for at the time application is made for the permit.

The rates at Detroit, Mich., are:

Brick, per 1,000	$0.05
Plaster, per 100 sq yd	.07
Concrete, per 100 cu. yd.	1.00
Concrete, 6 in thick or less, per 100 sq yd	.20
Tile, per 100 cu. ft.	.05
Each perch stone	.01

Cost of Meter Maintenance at Washington, D. C.—The average cost of water meter maintenance in the District of Columbia for the fiscal year ended June 30, 1916, was 33 ct. per meter.

METHOD OF PROVIDING DRAINAGE FACILITIES FOR 1ST ILLINOIS CAVALRY CAMP AT BROWNSVILLE, TEX.

Contributed by Charles E. De Leuw *

When the 1st Illinois Cavalry, after a hot and dusty trip from Illinois, arrived at its camp at Brownsville, Tex., on July 4, 1916, the camp presented anything but a prepossessing appearance. The first impression was not alleviated to any extent by a drink of the alkali water which had a temperature of about 90° F. It had rained in Brownsville on the day we arrived, and our hike to the camp, about two miles, was made in the middle of the day with the temperature well over 100° F.

The camp site which had been selected for us was, for some reason unknown to the writer, located mostly in a broad hollow or basin. It was in flat country covered with a dense growth of mesquite, chapparal, cactus, and other varities of thorny underbrush. On the camp site proper this brush had been partly cleared away. Water had been provided for us by a pipe line from the city of Brownsville water works, located on the Rio Grande River about ½ mile to the south. This pipe line was laid very close to the surface of the ground, and the camp distribution system, composed of galvanized wrought iron pipes of 2-in. diameter, was laid on the surface. As a consequence, the water was extremely hot and unpalatable.

Our first task after pitching our pyramidal tents, was to bury water pipes. This was done, by the troopers, throughout the camp, the pipes being given about 2 ft. of cover. This protected the pipes and materially lowered the temperature of the water.

Up to the day of our arrival we were told that there had been no rainfall for 18 months in the Brownsville district. Undoubtedly the people who selected our camp site thought that this drouth would continue indefinitely, but fortunately for us, our commanding officer, Col. Milton J. Foreman, after noting the topography, decided to make adequate preparation for draining the storm water. Possibly he was influenced in this decision by some of the citizens of Brownsville, who told us that our camp site had furnished an ideal duck pond in years previous.

The services of the writer were volunteered for this work, and the main ditches were laid out and their construction superintended by him under the general direction of Capt. J. A. Holobird. A reconnaissance proved that there was no outlet to the southwest. It would have required a ditch over ½ mile in length to reach the Rio Grande River. Moreover, the Rio Grande, at its bank full stage, which it was apt to reach at times of heavy rainfall, has a flow line which is a little higher than the low ground in the camp. Investigations proved that the camp site was in the bottom lands of the Rio Grande River. The entire district is subject to overflow at times, and may be considered as delta lands, the soil being a silty clay loam deposit. The general slope, as in the case in all bottom lands of this character, is slightly and uniformly away from the river.

However, an arroyo or large basin was discovered about 1,500 ft. southeast of the camp. The bottom of this arroyo, dry at that time, was found to be 10 ft. below the lowest ground in camp. This arroyo proved to have a storage capacity of more than 4,000,000 cu. ft.

The catchment area of which the camp was a part had an area of 90 acres. The time for investigation was somewhat limited so that no accurate survey of the catchment area of the arroyo was made. The writer estimated its area at about 200 acres, including the camp. About half of this area was in cultivation. The soil may be classed as Laredo silty clay loam. It is dark brown, sticky and plastic when wet, and with sufficient clay content to cause the surface to bake and crack during drouths. This soil is about 12 to 18 in. in depth and overlays a subsoil of a similar character but lighter in color, which when dry, can easily be crushed to fine dust. This subsoil is from 2 to 3 ft. thick and generally overlays a thick layer of fine sand mixed with loam.

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*Gates & De Leuw, Consulting Engineers, Chicago, Ill

The rainfall in this Brownsville district is extremely erratic. The records kept at Fort Brown show the maximum annual rainfall to be 60 in., the minimum 8 in., and the mean 28 in. The maximum daily rainfall recorded was in September, 1886, and amounted to 11.9 in. This was a part of a 48-hour storm during which there was a fall of 22.3 in. On the assumption that total run-off would be 50 per cent of the rainfall, this basin will provide a reservoir for a total rainfall of about 12 in.

Between the camp site and this arroyo another shallow basin intervened, which permitted a ditch location involving very shallow cut. There were also two public roads. The road near the arroyo had an existing 15-in. pipe culvert which was at a suitable grade, and it was used. A 15-in. pipe culvert was also laid under the road near camp. The ditch was constructed on a gradient of 0.1 per cent and with 2 ft. bottom and 1 to 1 slopes.

Mexican labor was employed in the digging of the ditch, except where teams could be used with plows and slip scrapers. The soil was very hard to handle and the great number of mesquite and chapparal roots made a great deal of grubbing necessary. In places inaccessible to the plow it was necessary to loosen the soil with pick mattocks. About half of the laborers were engaged thus and the balance removed the earth with long-handled shovels. As the maximum cut was 7 ft. the dirt was handled only once. The teams used cost $5 per 9-hour day and the Mexican labor cost $0.50 per 9-hour day, advancing later to $1 per day. Considering the difficulties in the way of baked clay, hard wood roots, and terrific heat, some very low costs were obtained. On one section of the main ditch 700 ft. long, containing 1,150 cu. yd. of excavation, the cost was $0.12 per cubic yard. This includes no charge for supervision, as troopers acted as foremen.

View Towards Middle Portion of Camp Immediately After Storm of July 12.

Mexican Laborers and Troopers Cutting Through 90-Ft. Highway.

Portion of Main Ditch on July 12.

The main ditch was just completed when we had an excellent opportunity for testing its effectiveness. It started raining about 1 a. m., July 12, and continued all morning, thoroughly saturating the ground. About 11 a. m. a terrific rainstorm broke and continued for an hour. By use of a rough rain gage I estimated the rainfall to be over 4 in., of which 2 in. fell in 1 hour. This torrential rainfall on the already saturated ground ran off quickly, and at such a rate that the 15-in. culverts backed the water up several feet, so that the main part of the camp was completely flooded. The situation was deemed serious enough to call out two troops and cut through both roads. This was done in about 2 hours' time. The road near camp was narrow and a simple timber bridge was constructed over the ditch. The stringers were composed of five 2x12-in. pieces spiked together and laid on a 2x12-in. sill. The span was 15 ft. A double floor was laid of 2-in. lumber, the bottom layer being laid at a 45° angle, and the top layer at right angles to the center line of the bridge. A handrail 3 ft. high, made of 2x4-in. lumber, was provided at each side.

The second road was about 90 ft. in width, and a much used highway, so a permanent wooden box culvert 4 ft. by 5 ft. inside dimensions was built. The frame work of this culvert consisted of 6x6-in. pieces with morticed joints. These frames were placed 5 ft. c. to c. The walls and top were of 2-in. lumber nailed to the frames. A number of small bridges were found necessary throughout the camp and were constructed. The work was done very creditably, under the supervision of a corporal, by cheap Mexican labor.

From that time, although there were a number of heavy rains, the drainage system proved adequate. It was found necessary to construct a substantial ditch along each troop street and picket line, as well as along the regimental street. In fact, every little depression had to be ditched because the soil seemed to be impervious, and it was very desirable to remove all pools and puddles. Shower baths were constructed at each end of the camp and connected to this drainage system. The arroyo was filled during the summer to a depth of about 3 ft., which spoiled a good drill ground for us, but proved adequate for the purpose for which it was used.

Substantial latrines were constructed and the seats provided with flyproof covers. These latrines were burned out daily with crude oil, and never at any time had an obnoxious odor. Our regulations provided for the burning of all garbage, including dish water. This was done in incinerators constructed of brick masonry. The incinerators were about 3 ft. by 3 ft. by 6 ft. in length. One end was open and a large iron pan served as a cover. The garbage was dumped into this pan and boiled down to a consistency at which it would burn. The fuel used was wood obtained from cleaning the camp and surrounding country.

Very little sickness of a serious character developed in the regiment. One or two cases of dengue fever, and quite a few cases of a peculiar skin disease, which was very disagreeable but not dangerous, occurred. The camp as we left it in October was a very attractive one. Floors and frames for the tents were built during the summer, the picket lines were well graded, the camp and surrounding country within a hundred yards of the camp was cleared and many temporary and serviceable sidewalks and roads were built all around camp.

In conclusion the writer might say that he has never been able to solve the question of why that particular site was chosen for our camp, and why so much was left to be done by the regiment, which as a matter of fact was not supposed to have engineers in its ranks. Probably the hypothesis was that a healthy regiment with intelligent officers would be able to solve all of its own problems of camp construction and that the attendant hard work would be good for them, which is well borne out by the conclusion.

The work of laying out a portion of the ditch and practically all the laterals was in charge of Sergeant R. G. Shankland of headquarters troop and the bridge and culvert construction was built under the supervision of Corporal Hooker of L Troop.

Cost of Reading Meters and Making Out Bills.—The total number of water meters in service on June 30, 1916, in the city of Los Angeles, Cal., was 82,233. The cost of reading the meters was $0.0104 per meter statement. The cost of making bills ready for collection, including 10.000 flat rate service bills was $0.0257 per bill.

FLOW MEASUREMENT IN A WATER-COLLECTING GALLERY BY THE CHEMICAL METHOD.

A somewhat novel application of the chemical method was employed last year in making measurements of the flow in the infiltration galleries of the Des Moines (Ia.) Water Co. The methods employed were described by Mr. D. H. Maxwell, Assistant Engineer with Alvord & Burdick, Consulting Engineers, Chicago, in a paper presented at the recent annual meeting of the Illinois Section of the American Water Works Association. In his paper, an abstract of which is given below, Mr. Maxwell calls attention to the adaptability of the chemical method for situations where satisfactory discharge measurement by the velocity area method are not possible.

Description of Galleries.—The total length of gallery completed and in use at the time of the test was 8,480 ft. Manholes are provided about 600 ft. apart. These galleries are built at a depth of from 20 to 25 ft. in the very extensive and uniform coarse sand deposits of the Raccoon River valley, and are submerged 5 to 10 ft. at low water. The newer part, 5,160 ft. in length, is built of concrete rings and has a cross-section of 12.6 sq. ft. The older galleries are rectangular and vary from 15 to 20 sq. ft. in cross-section. When yielding at the rate of the present maximum pumpage, 14,000,000 gals. per day, the average velocity at the lower end of the main gallery is only 0.9 ft. per second, the velocity decreasing progressively to practically zero at the far end.

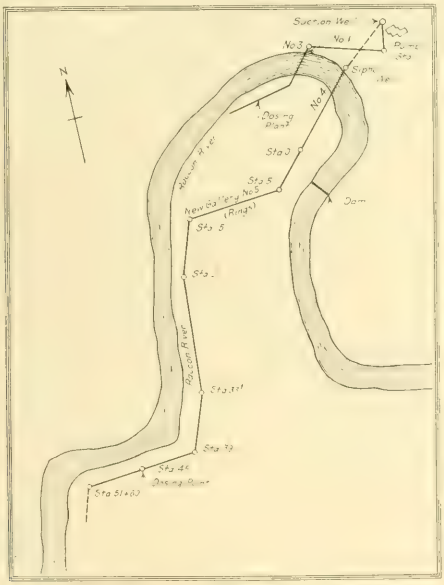


Fig. 1.—Plan Showing Location of Gallery Lines.

The location of the two main gallery lines with reference to the river, the principal source of supply, is shown on Fig. 1. The variation in distance from gallery to river, and the long continued use of the older galleries near or underneath the channel, with consequent clogging of the overlying sand, made it reasonable to suppose that the yield was not constant throughout the gallery length.

Purpose of Test.—In planning for the future extension of this supply, it was important to know the amount of variation in yield between different parts of the gallery from these causes. Measurements by current meter, made two years ago, were not entirely satisfactory because of the very low velocities in the gallery, and the difficulty of determining the average velocity of the cross-section. When the subject came up for study last year, it was decided to measure the flow by the chemical method, as better adapted to the conditions.

Method of Measuring Flow.—The test consisted in feeding a solution containing a known amount of salt (sodium chloride) at constant rate into one branch of the galleries near its upper end, and titrating for chlorine in samples of the gallery water collected at all manholes between the dosing point and the pumping station, including a sample at the pumps, just before the water entered the venturi meter. The chlorine determinations were expressed in parts per million. These determinations, corrected for normal chlorine, indicated the dilution at any given point, of the salt fed into the gallery, and gave a measure of the volume of flow at the corresponding point.

The equation for flow at any point is:

$$Q = \frac{c - c_2}{c_2 - c_1} q$$

in which Q is the gallery flow, q is the rate of dosing, c the concentration of the dosing solution, c the normal concentration of chlorine in the gallery water, and c_2 the concentration of chlorine in the gallery water at the sampling point, after dosing.

The volume of the dose was so small in comparison with the gallery flow, that it was ignored except to keep it constant. In other words, the salt used in making up the solution was carefully measured and was always added to the same quantity of water, but the exact amount of water in the solution was not determined.

Having determined the rate of flow at each manhole, the difference between the flows at successive manholes, gives the total infiltration rate of the gallery intervening, and this divided by the length, gives the average yield per unit length. This made it possible to compare in rate of yield the several lengths of the gallery as divided by the manholes.

The ideal condition for this test, of perfectly uniform draft on the galleries could not be secured. Des Moines has a direct pressure system and the pumpage fluctuates more or less continually. It was not practicable to overcome this difficulty by taking simultaneous samples at the several sampling points, so the test was continued during the greater part of the day, and the results used over selected periods of comparatively uniform pumpage, as shown by the venturi meter chart. In this way the results are based upon observations made under conditions approaching as nearly as possible the ideal of steady uniformly accelerated flow, that would pertain under contant draft. It is apparent that any departure from this condition would, in the absence of simultaneous samples, give a false indication of the amount of infiltration between sampling points.

A check on the total yield of the galleries computed by this method, was furnished by the venturi meter. In fact, having the venturi meter record of the total flow, it would not have been necessary for the purpose of this test to know the rate at which salt was added, although it was desirable to have this and use the meter as a check. The chlorine determinations might have been used merely to measure relative flow, and then compared with the chlorine determination at the venturi meter and the flow as measured by the meter, to compute the actual flow at any sampling point.

Details of Test.—Commercial sodium chloride was used for this work. The solution was prepared by dissolving a definite weight of salt (57 lbs.) in about 35 gal. of water, as needed in each of two barrels from which the solution was drawn alternately. Each barrel emptied in about 30 minutes. The barrels were piped into an orifice box, the water level in which operated a float level controlling the barrel discharge. A 3/16-in. orifice was provided under about 4-ft. head, the idea in using a small orifice and large head being to minimize the effect on the discharge of the slight fluctuations in head that were unavoidable with the float valve used. A 1-in. drop pipe with funnel at the upper end caught the solution below the orifice and delivered it to the center line of the gallery.

The dosing apparatus was not entirely satisfactory. Its principal defect was the imperfect arrangement for maintaining constant head on the orifice and absolute uniformity of feeding could not be secured with it. Some trouble was also experienced with small splinters in what appeared to be perfectly clean salt, becoming lodged across the orifice. This was overcome by straining the solution through cheesecloth as it entered the orfice box. This trouble with the feeding apparatus was the principal source of error in the work.

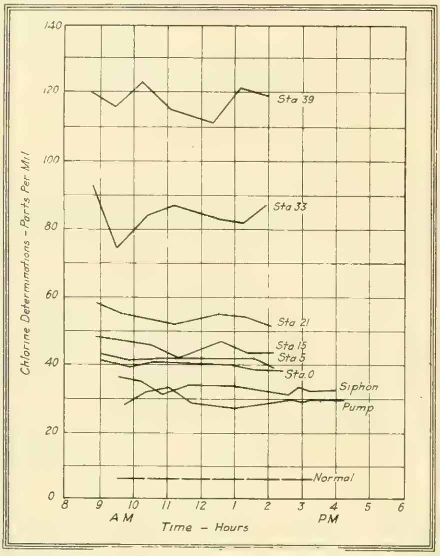


Fig. 2—Chlorine Determinations.

The quantity of salt used and the size of the orifice were predetermined to approximate the desired chlorine determinations in the final sample at the pumping station.

The dose was applied in the case of the main gallery test at a point 600 ft. from the upper end, with satisfactory results. The average velocity at this point during the test was about 0.113 ft. per second. In testing the shorter gallery, the dose was applied only 350 ft. from the dead end, and the results seemed to indicate that the velocity at this point (about 0.03 ft. per second) was too low for very satisfactory results.

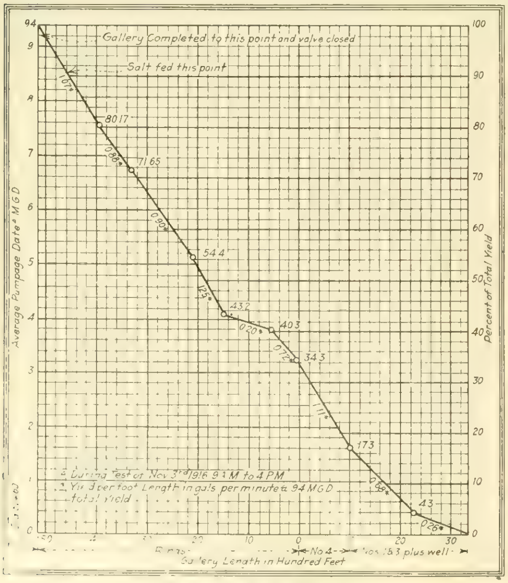


Fig. 3—Results of Tests.

Sampling.—Samples were collected at intervals of about one hour throughout the test, in 200 cc. bottles which were lowered into the manholes and opened as nearly as possible at the gallery center line. This precaution was necessary as at all the manholes there was considerable water standing in the shaft above the gallery, and this water doubtless lagged behind the main gallery stream in chlorine content. The care required in taking the sample and the distance apart of the half dozen or more sampling points, made it impracticable to take simultaneous samples, which would have made it possible to have conducted the test in less time.

Chlorine Determinations.—The samples were titrated with silver nitrate. In the main gallery test it was observed that during constant pumpage the chlorine determinations at each sampling point of continued practically constant (Fig. 2), giving a series of approximately parallel lines for the several sampling points. These values were averaged for each point.

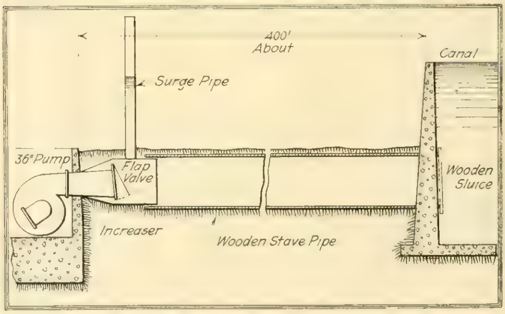
In testing the shorter gallery, the dose as already mentioned was applied at a point where the velocity was evidently too low for the best results. Diffusion of the salt interfered with the appearance of constant chlorine concentration at the sampling points even under constant draft on the gallery, and somewhat obscured the results.

Results of Test.—The results of the tests are shown on Fig. 3. The infiltration rates under constant draft on the galleries varied from 0.20 to 1.25 gal. per minute per foot length of gallery. By comparison with the plan showing gallery location (Fig. 1) it will be seen that the low rates were found in those sections of the gallery not adjacent to the river.

PUMP AND DISCHARGE PIPE ARRANGEMENT FOR IRRIGATION PLANT.

An arrangement of pump and discharge pipe whereby the velocity head is recovered by using an increaser is described by B. S. Nelson, Engineer A. M. Lockett & Co., Ltd., New Orleans, La., in the March Journal of the American Society of Mechanical Engineers. The installation was made for an irrigation plant near Pharr, Tex.

The pump in this installation is about 400 ft. away from the concrete bulkhead of the canal. The discharge pipe is a wooden-stave pipe about 7 ft. in diameter. One end of this pipe connects to this concrete bulkhead; the other end runs back to within a short distance of the pump. On the discharge of the pump an ordinary sheet-iron increaser, with an inexpensive flap valve on the end, is used to recover the velocity head. This valve was about 5 ft. in diameter. On the outside of the increaser is riveted a larger cone, one end fastened to the increaser and the other to the wooden pipe.



Arrangement of Pump and Discharge Pipe.

The advantages of this arrangement were that the velocity head was recovered by using an increaser; an inexpensive flap valve was substituted for an expensive gate valve, and the pump could be primed without priming the long discharge pipe.

There is no trouble about getting at the flap valve, because a sort of wooden sluice gate was arranged which could be let down over the bulkhead end of the wooden pipe and this pipe then drained back through the pump so that workmen could get into it.

TESTS OF A NEW PROCESS OF SEWAGE PURIFICATION WITH GREASE RECOVERY AND APPARENT PROFIT.

Tests of the Miles process of sewage treatment conducted in July and November of last year under the supervision of the Sanitary Research Laboratory of the Massachusetts Institute of Technology gave results that lead to the recommendation that an experiment on a large scale to settle all question of doubt be made by the city of Boston. This process was invented and patented by George W. Miles, a Boston chemist. It attempts, by the addition of an acid, to precipitate the bulk of the solids from sewage in the form of a sludge which can be dried and degreased, thereby producing a readily soluble and greaseless fertilizer, as well as recovering the valuable grease. Either sulphuric acid or sulphurous acid may be used, and the process contemplates the manufacture of the acid at the disposal works.

Experiments with the Miles process were conducted by Mr. E. S. Dorr, Engineer Boston Public Works Department, and other officers of the Sewer Division of the city of Boston, at different times between June 20, 1911, and June 29, 1914. In all 11 runs were made and 25,986 gal. of sewage were treated. From these experiments Mr. Dorr concluded that he could obtain from 1,000,000 gal. of sewage 1,738 lb. of dry sludge containing 21.7 per cent of grease, which at 4 ct. a pound would yield $15.02 per 1,000,000 gal. In addition there would be 1,861 lb. of fertilizer base produced per 1,000,000 gal. of sewage, which was estimated by Mr. Dorr according to agricultural standards to be worth $13.57 per ton or $9.25 per 1,000,000 gal., making the total value of the recoverable materials about $24.33.

The more recent experiments at the Sanitary Research laboratory were carried out under the direction of Mr. Robert Spurr Weston, Assistant Professor of Public Health Engineering, and in a recent report to the Mayor of Boston he outlines the results. Extracts from the report follow:

The experimental devices consisted of two wooden settling tanks, a trough for mixing the acid and sewage, a supply pipe for raw sewage and devices for applying sulphur dioxide gas to the water. Settling tank No. 1 was built of wood. It was 15.3 ft. long, 3.02 ft. wide and had a depth of 3.98 ft. to the flow line. Its capacity was 1,352 gal. Settling tank No. 2 was of the same construction and area as tank No. 1, but its depth was only 3.61 ft., corresponding to a capacity of 1,227 gal. below the flow line.

The amount of sulphur dioxide gas added was determined by frequent weighings of the tank from which the gas was supplied, and by noting the acidity of the treated sewage from time to time, usually every half hour. The acidity of the treated sewage was measured at the inlet and outlet of tank No. 1 and at the outlet of tank No. 2, respectively. It was determined by titrating with standard alkali, using methyl orange as indicator.

Beginning at 1 p. m. July 7, a continuous test of the process was made until 3.22 p. m., July 14, when the supplies of sewage and gas were stopped, the sewage decanted from the sludge and the latter measured and dried.

At 3 p. m. on July 15 the mixed sludge from tank No. 1 and tank No. 2 was placed upon a cinder bed to a depth of 6 in., and the same sludge, dried, was removed on July 22—seven days thereafter.

At 12 o'clock noon on July 16 mixed sludge from tank No. 1 and tank No. 2 was acidified with 0.1 per cent of sulphuric acid (the percentage being based upon the weight of wet sludge) and placed upon a cinder bed to a depth of 3 in., and this sludge, dried, was removed on July 19—three days thereafter.

At noon on July 16 another portion of the above mentioned acidified sewage was applied to a cinder bed to a depth of 9 in. and the dried sludge removed on July 26—ten days thereafter.

A charge of 12 gal. of the acidified mixed sludge was dried in a steam-heated rotary dryer furnished by the Wheeler Condenser & Engineering Co. A charge of 12 gal. was dried in an hour, and about 4 lb. of steam at approximately 45 lb. pressure were used to heat the dryer. The mechanism of the dryer was driven by a belt from a small vertical engine and 36 lb. of steam at approximately 45 lb. pressure were used by this engine. A second charge of 9 gal. of the same sludge was used and dried in the same way in 50 minutes, but no better results were obtained.

The November experiments began at 3 p. m. on Nov. 8 and continued for 72 hours, exclusive of stoppages. From 5:23 p. m. to 5:45 p. m., and 5:55 to 8:17 p. m. on Nov. 8, the experiment was interrupted for the making of some repairs. Again on Nov. 9 the experiment had to be stopped between 5:35 and 7:02 a. m. because the liquefied sulphur dioxide got so cold that it could not be fed from the tanks into the stream of sewage fast enough. The test was, therefore, extended for a period corresponding to the time taken out for repairs and because of lack of gas, but was brought to a conclusion at 7:11 p. m. on Nov. 11.

On one or two occasions during the test, the effluent from the settling tank was slightly alkaline, because of insufficient gas having been added. In other respects the experiment was conducted like that made in July.

An excess of acid was added to the sewage at all times; otherwise the sludge would not precipitate. In general terms this excess must amount to about 10 per cent of the total acid added. The average amounts of acid added each day, both during the July and the November experiments, are given in the following tables. These tables show that in July the effluent from tank No. 1 contained on the average an excess of 55.9 parts of SO_2 per million, and in November the effluent from the same tank contained an excess of only 22.1 parts of free acid per million. In July it was believed that an unnecessary excess of acid was added and consequently during the November experiments the excess was reduced as much as the rather crude apparatus for adding the acid would permit. As the result of the attempt to reduce the amount of acid in November, on two occasions the effluent from the settling tank became slightly alkaline. Nevertheless, it is believed that on an average an excess of acid not exceeding 35 parts of SO_2 per million may be used to bring about the optimum degree of sludge precipitation.

EXCESS ACIDITY JULY 7-14, 1915.

Period.	Sulphur dioxide. Parts per million. Tank No. 1. Effluent.	Sulphur dioxide. Parts per million. Tank No. 2. Effluent
1st 24 hours	25.6	....
2d 24 hours	68.8	83.5
3d 24 hours	50.2	57.6
4th 24 hours	79.0	63.0
5th 24 hours	....	....
6th 24 hours	68.5	56.6
7th 24 hours	42.6	51.8
Average	55.9	62.5

EXCESS ACIDITY NOVEMBER 8-11, 1915.

Period.	Sulphur dioxide. Parts per million. Tank No. 1. Effluent	Sulphur dioxide. Parts per million. Tank No. 2. Effluent
1st 24 hours	20.7	20.7
2d 24 hours	17.0	12.6
3d 24 hours	28.6	30.4
Average	22.1	21.2

Volume of Sewage.

The following table shows the number of gallons of sewage treated daily, and also the amount of sulphur dioxide gas used daily. The table shows also the total period of subsidence in both tanks. No allowance was made for imperfect displacement in the tanks. The figures represent the capacity of the tanks in terms of hours flow. Tank No. 1 removed the bulk of the sludge, namely, about 78 per cent of that removed by the two tanks in series.

TABLE SHOWING VOLUMES OF SEWAGE, AMOUNTS OF ACID AND PERIODS OF SUBSIDENCE JULY 7-14, 1915.

Period	Gallons per day	Sulphur dioxide. Pounds of SO_2 added	Sulphur dioxide. Pounds per million gallons	Sulphur dioxide. Parts per million	Total settling period, hours
1st 24 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2d 24 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3d 24 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4th 24 hours	7,805	16,350	2,096	251.3	7.93
5th 24 hours	[illegible]	15,819	2,011	241.7	7.99
6th 24 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7th 24 hours	8,030	15,575	1,940	232.6	7.71
Total	8,241	15,689	1,911	229.1	7.54

The results of analyses of the wet sludge collected from tanks No. 1 and No. 2 during the July and November experiments, respectively, are as shown below The wighted average result of the two experiments is as follows:

QUALITIES AND COMPOSITION OF SLUDGE

Moisture in wet sludge	88.80%
Fats in dried sludge (by ether)	22.66%
Pounds of wet sludge per million gallons	13,400
Tons of wet sludge per million gallons	6,720
Parts of wet sludge per million	1,612
Pounds of dry sludge per million gallons	1,909
Tons of dry sludge per million gallons	0.9545
Parts of dried sludge per million	228.9
Pounds of grease per million gallons	430.1
Tons of grease per million gallons	0.2151
Parts of grease per million (in sewage)	51.6
Average total gallons treated per twenty-four hours	7,890
Average pounds of sulphur dioxide used per million gallons	1,961
Average parts of sulphur dioxide per million	235.1
*Average detention period—hours	7.72

*Two tanks in series. Detention period, four hours.

RESULTS OF SLUDGE DRYING EXPERIMENTS, JULY, 1915.

Sample No.	Description of sample.	Substance determined	Percentage of substance.
3929	Sludge from Tank No. 1.	Moisture Fats in dry sludge (by ether)	79.91 22.5
3930	Sludge from Tank No. 2.	Moisture Fats in dry sludge (by ether)	93.88 21.5
3931	Mixed sludge from shallow depth bed—3-in. sludge.	Moisture Fats in dry sludge (by ether)	54.99 17.5
3932	Mixed sludge from medium depth bed—6-in. sludge.	Moisture Fats in dry sludge (by ether)	52.75 16.4
3933	Mixed sludge from steam dryer.	Moisture Fats in dry sludge (by ether)	22.27 15.6
3935	Mixed sludge from deep bed—9-in. sludge.	Moisture Fats in dry sludge (by ether)	60.03 15.74

The mixed sludges from tanks No. 1 and No. 2, respectively, were dried in various ways, as described above. The moisture and fat in the sludges after drying at different depths for different periods are shown in this table.

The sludge in the 3-in. bed and that used in the steam dryer were acidified with 0.1 per cent of sulphuric acid before drying.

The specific gravity of the wet sludge was 1.036 and it contained ony 81.6 per cent of water at the time it was mixed and applied to beds and dryer. An unusual dryness of the sludge from this acid process is noteworthy.

In the following table are given the results which are common to both investigations:

COMPARISON OF AVERAGE RESULTS OF TREATING SEWAGE WITH SULPHUROUS ACID, AS SHOWN IN EXPERIMENTS BY E. S. DORR AND M. I. T. SANITARY RESEARCH LABORATORY, 1912-1914 AND 1915, RESPECTIVELY.

	Experiments by E. S. Dorr.	Experiments by M. I. T. Sanitary Research Laboratory.
Average daily flow of sewage during experiments, gallons	92,511,617	103,498,049
Average amount of dry sludge per million gallons of sewage	1,814	1,909
Average percentage of grease in dry sludge	22.33	22.66
Average amount of grease precipitated from sewage, pounds per million gallons	436	430.1
Average amount of sulphur dioxide used, in pounds per million gallons	2,300	1,963

Approximate

The close agreement between the results of the two sets of experiments is remarkable. During the experiments by the Sanitary Research Laboratory a larger amount of sludge was recovered, but a smaller amount of grease per 1,000,000 gal. of sewage. On the other hand, the percentage of fat determined by both sets of observers was approximately the same. The mean flow of sewage during the Sanitary Research Laboratory experiments was about 11 per cent higher than the average flow of sewage during Mr. Dorr's experiments.

SUMMARY OF RESULTS AND ANALYSIS

July Experiments.

Sludge from tank No. 1	
Moisture	79.91%
Fats (by ether) (on dry sludge)	22.5 %
Sludge from Tank No. 2	
Moisture	93.88%
Fats (by ether) (on dry sludge)	21.5 %
Pounds of wet sludge	648.5
Pounds of wet sludge per million gallons	11,280
Tons of wet sludge per million gallons	5,640
Parts of wet sludge per million	1,353
Percentage of moisture of mixed sludge (weighted average)	81.58%
Pounds of dry sludge	119.5
Pounds of dry sludge per million gallons	2,080
Tons of dry sludge per million gallons	1,040
Parts of dry sludge per million	249.2
Percentage grease of mixed dried sludge (weighted average)	22.38%
Pounds of grease	26.73
Pounds of grease per million gallons	465.3
Tons of grease per million gallons	.2327
Parts per million of grease in sewage	55.3
Total gallons of sewage treated	57,440
Total pounds of SO_2 used	109.82
Total pounds of wet sludge	648.5
Total detention period, hours (2 tanks)	*7.54

November Experiments.

Sludge from Tanks Nos. 1 and 2:	
Moisture	92.18%
Fats (by ether) (On dry sludge.)	23.08%
Sludge from Tank No. 2:	
Moisture	94.77%
Fats (by ether) (On dry sludge.)	24.88%
Pounds of wet sludge per million gallons	18,910
Tons of wet sludge per million gallons	9,455
Parts of wet sludge per million	2,267
Pounds of dry sludge per million gallons	1,479
Tons of dry sludge per million gallons	0.739
Parts of dry sludge per million	177.3
Pounds of grease, soluble in ether, per million gallons	341.3
Tons of grease, soluble in ether, per million gallons	0.171
Parts per million of grease soluble in ether	40.91
Total gallons of sewage treated	22,720
Total pounds of SO_2 used	47.47
Total pounds of wet sludge	429.5
Total detention period, hours (2 tanks)	*8.17

*Detention period, 4 hours.

COMPARATIVE COSTS OF STERILIZATION BY HYPO AND LIQUID CHLORINE.

Comparative figures on the use of liquid chlorine and hypochlorite of lime at a filtration plant were given by Mr. M. S. Dutton of the Central Illinois Public Service Co., Mattoon, Ill., in a paper presented last month at an annual meeting of the Illinois Section of the American Water Works Association. The following notes are taken from Mr. Dutton's paper:

The plant was put in operation the latter part of January, 1915. The water supply is taken from a small stream and is at all times subject to contamination by sewerage and waste water from coal mines. The supply is pumped from the stream by two triplex plunger pumps from a low-lift pump house, ¾ mile to the filtration plant. It flows through a weir box, mixing chamber, two coagulating basins, three filter units, and thence to a clear well under the filter building. From this clear well the water flows to another larger clear well from which the service pumps take their suction. A very satisfactory place for the application of either liquid chlorine or hypochlorite of lime has been the 8-in. pipe connecting the two clear wells. This place of application has eliminated any loss of chlorine due to direct contact with the air and due to splashing water. The plant has a capacity of 900,000 gal. per day and was constructed with tanks for applying hypochlorite. In February, 1916, it was decided to purchase a chlorinator. A comparison for the month of January, 1916, when hypo was used and for the month of June, 1916, when liquid chlorine was used, shows the following:

	January.	June.
Total pumpage, gal	10,230,700	8,501,500
Average daily pumpage, gal	330,000	283,380
Total hypo used, lb	153.2	....
Total liquid chlorine used, lb	....	12

With hypochlorite at 7 ct. per pound and liquid chlorine at 20 ct. per pound, the average cost of sterilization by means of hypochlorite was $1.07 per million gallons of water treated and $0.28 per million gallons when using liquid chlorine.

The average reduction in bacteria count of daily plates made on nutrient agar incubated at 37° C. for 24 hours was as follows: In January, when hypochlorite was used, the average raw water count was 6,300 and the filtered water count was 15. In June, when liquid chlorine was used, the average raw water count was 7,980 and the filtered water count was 11. In Bacillus Coli tests the raw water shows 100 per cent for both months, while the filtered water shows 1.6 per cent in January and 0.0 per cent in June. These results were obtained by means of 1 c.c. samples in all cases. While hypochlorite was used 0.46 p.p.m. of chlorine was applied and while using liquid chlorine 0.22 p.p.m. of chlorine was applied.

THE RAILROADS AS AN UNDEVELOPED FIELD FOR THE SALE OF WATER.

The differential treatment of large consumers as a means for increasing water sales, particularly to the railroads was discussed by Mr. C. R. Knowles, superintendent of water service, Illinois Central R. R., in a paper presented November 13 at the annual meeting of the Illinois Section of the American Water Works Association. An abstract of the paper follows.

The consumption of water for all purposes by the railroads of the country is estimated to be nearly 700,000,000,000 gal. per year. Compared with this enormous figure the water purchased from city plants is small, and it would appear that the railroads are undeveloped as a field for the sale of water. This brings ups the question as to what should be the relation of the railroad to the city water plant. Should it be the same as the ordinary householder using only a few thousand gallons, or that of a large, long hour, high load factor consumer, whose business permits of utilizing the reserve pumping capacity, thereby increasing the efficiency of the plant.

The cost of supplying water may be divided into two charges: first, the fixed expense or cost of readiness to serve, which remains the same regardless of whether the plant is operated to full capacity or not; second, the operating expense which varies with the amount of water pumped. Assuming the plant has ample reserve capacity, the cost of furnishing water to the railroad or other large consumer will consist of the fuel, chemicals, oil, waste, etc., any return in excess of the actual operating expenses for such water furnished may be applied to the reduction of the overhead expense, to other consumers.

Companies furnishing electricity for power are probably the most efficiently conducted public service institutions in existence. The efficiency is largely attained through operating the power plants to their full capacity by securing an output for the power reduced through attractive rates to large consumers utilizing the off-pack load. The prevailing rates for electric power in Illinois are from 4 to 11 cent per kilowatt hour. Special rates for large, long hour, high factor consumers and discounts for off-peak service, however, brings the cost down to 1 and 1½ cent per kilowatt hour. The electric power companies have made these low rates for two reasons: first, that the highest efficiency is attained when the plant is operated under full load and from a realization of the fact that there is a limit to charges that may be made for electricity, and that limit is reached where the cost of current equals the cost of steam or other power.

The same thing is true of a railroad water supply. The limit is reached in cost of water from city plants when the cost equals or is in excess of what it will cost the railroad to pump its own water. The railroad is in a position to say what the water should cost by reason of having a water department organization, and perhaps in this respect has a different relation to the water plant than other large consumers. The fallacy of a universal rate for water to all consumers regardless of consumption is recognized by most waterworks managers, and sliding scales of rates are established in many instances. These rates are, of course, based upon all expenses, fixed and otherwise, and do not provide for differential treatment of large consumers where it is necessary to make certain concessions in order to hold the business or secure new custom.

No better exposition of the advantages of differential treatment of customers can be given than that of Messrs. Knowles and Scharff in their paper on "The Relation of out-of-pocket cost to rate making" in the proceedings of the Illinois Water Supply Association 1914 as follows:

> There remains, then, only the second basis which seems to us proper as a reason for differential treatment of consumers in order to lower the cost to other consumers by retaining custom which would otherwise be lost. How this works out may be very readily explained. Assume a small water works with a gross income, which must be collected when it is supplying 1,000,000 gal. per day, of $35,000. Now, suppose one large consumer using 100,000 gal. per day and paying $3,500 per year should find that he could secure water elsewhere at a cost of $2,500 per year, and should disconnect from the mains. The amount supplied would drop to 900,000 gal. per day, but interest, depreciation and maintenance would remain practically the same. It would still be necessary to have the same number of engineers and firemen, and the only saving would be a small amount of fuel, alum, hypochlorite, oil and waste, etc., which would certainly not be in excess of $1,000 per year and would probably be a great deal less. So that the gross income to be raised might be reduced to say $34,000, all of which would have to be raised from other consumers. Now, if all other conditions remained the same, and the rate for the large consumer were reduced so as to just hold his custom, when paying $2,500 per year, the total gross income would still be $35,000, and the portion to be raised from consumers other than the large one would be $32,500, or $1,500 less than in other cases. Their rates could, of course, be correspondingly lower than would be necessary if the large consumer were lost. The advantage of such an arrangement to all of the consumers is obvious, and such differential treatment, if necessary to secure this advantage, would not only not constitute discrimination, as we have defined it, but would appear to be a plain duty of the water works as a public utility.
>
> In brief, it is to the advantage of all consumers that large, long hour, high load factor consumers be retained. Differential treatment of them does not constitute discrimination, so long as it will result in advantage and saving to other consumers. Such concessions in rates, however, must not be greater than actually necessary to meet the competition of other sources of supply, as in any case they must not be so great as to increase instead of decreasing the income to be collected from other consumers. Thus in the case above cited, if it were possible to get the business at $2,500, any rate less than that sum would constitute discrimination. While if it were really necessary, in order to meet competition, any rate greater than $1,000 per year would effect some saving for other consumers and would be justifiable. A rate less than $1,000, however, would make the amount to be collected from other consumers greater than if the large consumer ceased entirely to take service. This would certainly be discrimination under our definition.

In view of the facts as to rate making as brought out above it would appear that in many instances more attractive rates could be made the large consumers such as railroads rather than suffer the loss of business that will perhaps decrease the income to such an extent as to make it necessary to increase the rate for water furnished the remaining consumers to make up the deficit. Aside from the advantage of the large consumer in keeping down the unit cost through absorbing a portion of the overhead or readiness to serve expense, a number of instances might be cited where the acquisition of one or two large consumers has made it possible to enlarge and improve the pumping plant and even construct new plants.

A writer in Engineering and Contracting of July 12, 1916, strongly advises the waterworks managers cultivate a wider market for the sale of water by encouraging irrigation of truck farms and family gardens. He states further "Water is a marketable commodity. Were as much ingenuity expended in marketing water as in electricity there is probably not a waterworks plant in America that would not be able to double the quantity of water sold." Undoubtedly there are great possibilities in encouraging new uses for water, but as water is one of the prime necessities in the operation of a steam railway the market is already at hand and waterworks managers would have but little difficulty in finding a market for the sale of water if they would apply the same methods that prevail along other business lines, namely, divide up the profits with the customer if necessary to get the business.

Cost of Installing Meters at Washington, D. C.—During the fiscal year ended June 30, 1916, 5,880 water meters were installed by the Water Department of the District of Columbia, the average cost of installation per meter being as follows:

Meter	$ [illegible]
Material	3.37
Labor	[illegible]
Total	$11.27

The average force engaged was as follows:

Master plumber, half time	1
Plumber	1
Laborers	13
2-horse team	1

The following is an estimate of the raw materials that would be required annually in the production of 20,000 tons of armor plate at the proposed $11,000,000 government plant: Coal, gas producing, 150,000 tons; coal, steaming, 150,000 tons; Bessemer pig, 30,000 tons; nickel, 1,200 tons; ferrochrome, 2,600 tons; ferromanganese, 200 tons; ferrosilicon, 50 tons; limestone, dolomite, fluorspar (fluxes), 5,000 tons.

DEVICES FOR MEASURING WATER LEVEL IN WELL AND DISCHARGE OF PUMP.

In connection with some tests on motor-driven deep well pumps by I. W. Fisk and P. S. Biegler of the Department of Electrical Engineering of the University of Illinois, the apparatus shown in the accompanying illustration was developed for measuring the water level in the well. A calibrated bucket also was used for the measurement of the discharge of the pump. The tests were described by Messrs. Fisk and Biegler in a paper presented at the recent meeting of the Illinois Section of American Water Works Association, from which the following notes are taken.

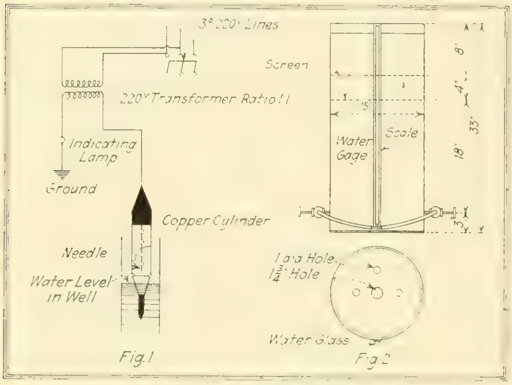


Fig. 1—Device for Measuring Water Level in Well.
Fig. 2—Orifice Bucket for Measurement of Discharge.

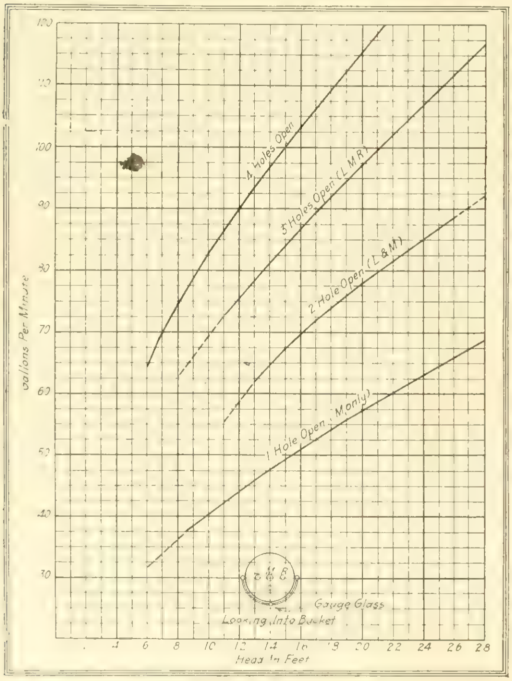


Fig. 3—Calibration Curves for Orifice Bucket.

The apparatus developed by Messrs. Fisk and Biegler for the measurement of the height of water in the well is easily made sensitive to a change in water level of 1/10 in., the only difficulty being the small space within the well casing into which the device must be lowered to get the water level while the pump is in operation. The device is easily lowered into the well when the pump has been pulled.

From the diagram of connection it is seen that when the end of the circuit being lowered into the well touches the water a circuit, established through the ground, is complete, lighting the indicating lamp. The use of a transformer in this circuit is simply to avoid grounding one of the service wires. The needle forms one end of the electric circuit and is protected from grounding on the iron pipes by means of a shielding cylinder from which the needle is insulated.

The calibrated bucket used in the tests is shown in Fig. 2. This bucket has holes in the bottom which may be changed according to the rate at which water is delivered by the pump. A glass gage registers the height of water in the bucket, and this gage reading may be converted into gallons per minute by reference to Fig. 3. By this means any peculiar characteristics of the discharge may be noted which might pass unobserved if the discharge is measured, for instance, by taking the time required to fill a tank. This device was originally designed by Prof. M. L. Enger, University of Illinois.

PROTECTION OF METERS FROM FREEZING.

The Gary, Heat, Light & Water Co. of Gary, Ind., has adopted the practice of sending the handbill, shown in the accompanying illustration, to all customers furnished water by meter measurement. The handbill is delivered about Dec. 1 of each year and it is believed that it has served to reduce the number of cases of frozen meters to a minimum. The company also co-operates with the plumber making the service pipe installation to the end that a suitable location is provided for the meter where it is least exposed to frost. It also is the aim to use for those places only such meters as can be repaired at the least possible cost. The company's experience has been that these precautions aid in reducing the loss due to meters being frozen and results in better service given the customers.

G H 58 4011 [illegible]

Protect Your Water Meter

Avoid Unnecessary Expense and Damage
BY
Protecting Your Meter From Frost.

PLEASE ATTEND TO THIS AT ONCE

Acquaint Yourself,

Your Family, or Employees with the Location and Use of the Valve and See That It Is Always in Good Working Order.

You Will Find

This Valve in the Water Pipe Line where It Enters the Basement or Building. In case a Pipe Should Burst

YOU CAN SHUT OFF THE WATER at this valve.

In your meter application

You Have Agreed

"to fully protect the meter from freezing" and to pay the cost of repairs of any damage resulting from this cause.

This Is a Suggestion For Your Welfare.

RESPECTFULLY,
Gary Heat, Light & Water Co.

Hand Bill Used by Gary Heat, Light & Water Co.

SOME CONSTRUCTION NOTES ON LINING THE 3-MILE WATER TUNNEL OF CLEVELAND WITH SEGMENTAL CONCRETE BLOCKS.

The new 3-mile Lake Erie water supply tunnel of the city of Cleveland, Ohio, is lined with segmental concrete blocks. The entire job will require over 65,000 blocks. The plant where the blocks are made is a 1-story frame structure, with saw-tooth roof, and built especially for the purpose. It has been enlarged at two different times since the work was begun early in 1914 and now covers an area of 100x211 ft. The building is of especial construction, every advantage being taken towards efficient operation, and so well has this been planned the loss in the manufacture and handling of the block practically is negligible, there being less than one block lost in every 700 made.

Sand and stone are brought to the building in hopper-bottom cars by a Plymouth gasoline, friction drive locomotive. The track is elevated 26 ft. from the main floor. The bins to receive the storage of the material are located under this elevated truck. The sand and stone fall directly into these bins, where they follow a chute at the bottom and are conveyed still further, as required, by gravitation to the hopper of the ½-yard Smith mixers. These hoppers, however, are so large that gravitation alone will not move the material efficiently, so that an ordinary drag scraper, connected up with a double-drum hoisting engine, is employed to keep the stone and sand within reach of the chutes.

Plymouth Locomotive with Load of Segmental Block.

This hoisting engine is located on a decking above the bins and operates the drag scraper both forward and backwards, the cables being carried through block and tackle hooking into rings at suitable points around the walls of the bins, thus enabling the scraper to cover the bins thoroughly.

The Smith mixer dumps into the buckets of two telphers. These telphers are made by the Brown Hoisting Machinery Co. of Cleveland, and are an adapation of the Brownhoist mine telpher. These conveyors run on overhead I-beams, a series of which is carried throughout the plant, one over each casting alley. They are operated by electricity supplied by trolley wires paralleling the I-beams, and each carries a ½-yard side-dumping concrete bucket and a seat for the operator.

The buckets have a somewhat restricted discharge in order that the concrete may not be dumped faster than it can be spaded into place. There is, as a consequence little or no waste concrete spilled on the floor. A series of switches make it possible for the operator to direct the line of travel down any desired alley.

The two telphers also are used to handle the finished block, by means of tongs, on to the cars. The Plymouth locomotive then takes these cars to the yard for curing of the block. On the return trip the train takes back a 1 car of cured block to the tunnel and returns to the plant.

Three shifts of men are worked at the plant, but pouring is done only by one shift—the day crew, which works from 8 a. m. to 4 p. m.

The average output is 240 blocks per day, but added to this are some 300 or more key blocks and an equal number of plugs.

The day crew is composed of the following:

Operating Plymouth Locomotive	1
Unloading material	5
Feeding stone and sand into hopper	1
Feeding cement into hopper	1
Operating Smith mixer	1
Tending switches and cleaning tracks	1
Operating Brownhoist telphers	2
Dumping concrete from buckets	2
Distributing and tamping	6
Miscellaneous work—assembling, pointing up, spotting forms, placing steel, making keys and plugs and finishing and dating	14

There are only two men in the second shift, which works from 4 p. m. to midnight. Their duty is to strip the block from the forms cast the previous day.

The third shift consists of 20 men. This crew goes on duty at midnight and works until 8 a. m. It cleans, oils and assembles the forms and operates the Plymouth locomotive and one Brownhoist telpher in getting the cured block to the storage room.

AVERAGE COSTS OF SEWER CONSTRUCTION AND MATERIALS FOR THE LAST 15 YEARS.

The accompanying tabulation from the report of A. E. Phillips, superintendent of sewers, of Washington, D. C., for the fiscal year ended June 30, 1916, shows the average cost of constructing pipe sewers in that city for the past 15 years. Contract prices for materials used in this work also are given. It will be noted that the cost of the sewers and the materials were lower last year than they were in 1902:

TABLE I.—AVERAGE COST OF CONSTRUCTING PIPE SEWERS FOR 15 YEARS.

	8-in. diameter.		10-in. diameter.		12-in. diameter.		15-in. diameter.		18-in. diameter.		21-in. diameter.		24-in. diameter.	
Year.	Labor.	Material.	Labor.	Material.	Labor.	Material.	Labor.	Material.	Labor.	Material.	Labor.	Material.	Labor.	Material.
1902	[illegible]	$0.32	$0.97	$0.41	$1.04	$0.46	$1.16	$0.62	$1.74	$0.78	$1.91	$0.90	$2.13	$1.23
1903	.80	.36	1.03	.53	1.09	.74	1.32	.73	1.72	.81	1.57	1.06	1.74	1.32
1904	.97	.30	.92	.55	1.17	.65	1.47	.81	1.51	.91	1.94	1.24	2.24	1.47
1905	.98	.38	.96	.55	1.19	.60	1.41	.77	1.45	.89	1.92	1.01	1.87	1.43
1906	.87	.33	1.19	.47	1.26	.54	1.41	.67	1.53	.78	1.88	[illegible]	2.45	[illegible]
1907	1.12	.43	1.13	.48	1.30	.56	1.46	.70	1.82	.85	2.09	.98	2.78	[illegible]
1908	1.34	.42	1.26	.50	1.4	.61	1.69	.75	1.91	.90	1.73	1.14	3.65	1.50
1909	1.31	.36	1.10	.46	1.16	.46	1.59	.56	1.58	.62	[illegible]	[illegible]	1.91	1.18
1910	1.00	.29	.99	.35	1.12	.43	1.19	.52	1.19	.66	[illegible]	.85	1.72	1.14
1911	1.01	.27	1.07	.32	1.17	.40	1.36	.57	1.64	.57	1.50	.75	1.82	[illegible]
1912	1.06	.25	1.08	.33	1.20	.39	1.46	.50	1.63	.67	1.30	.88	1.76	.98
1913	1.02	.26	1.07	.29	1.35	.38	[illegible]	[illegible]	1.74	.65	[illegible]	1.08	2.20	1.28
1914	.78	.28	1.08	.45	1.32	[illegible]	1.11	.69	1.56	.85	[illegible]	1.31	2.11	1.11
1915	[illegible]	.19	1.12	.42	[illegible]	.51	1.56	.64	1.63	.80	[illegible]	1.18	1.78	1.45
1916	.76	.25	1.00	.36	1.05	.43	1.31	.62	1.19	[illegible]	[illegible]	1.13	2.11	1.16

TABLE II.—CONTRACT PRICES FOR CONSTRUCTION MATERIALS FOR 15 YEARS.

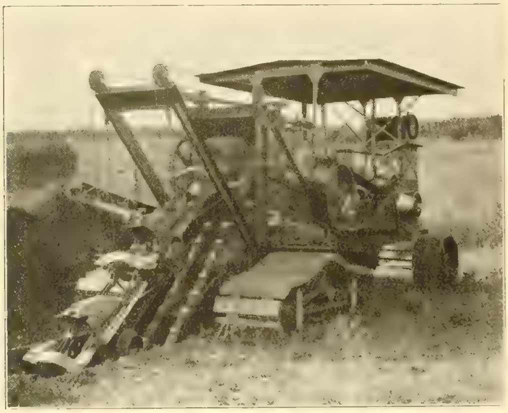
	Cement,	Sand,	Gravel,	Terra-cotta pipe, linear foot						
Year.	per bbl	per cu yd	per cu yd	8 in	10 in	12 in	15 in	18-in	21 in.	24-in
1902	$1.82	[illegible]	$0.88	$0.115	$0.17	[illegible]	[illegible]	[illegible]	$0.59	$0.77
1903	1.96	[illegible]	[illegible]	[illegible]	.18	[illegible]	[illegible]	.42	.62	.80
1904	1.75	.85	.85	.12	.228	.297	.401	[illegible]	.7425	[illegible]
1905	1.13	.81	[illegible]	[illegible]	.20	[illegible]	[illegible]	.50	.71	.96
1906	1.35	.85	1.05	.122	.1647	.2236	.2997	.3672	[illegible]	.7263
1907	1.55	.74	.97	.155	.195	.261	.353	[illegible]	.5451	.848
1908	[illegible]	.81	1.04	[illegible]	[illegible]	[illegible]	[illegible]	.51	[illegible]	[illegible]
1909	1.20	[illegible]	.75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1910	.975	.54	.65	.125	.15	.20	.27	[illegible]	[illegible]	[illegible]
1911	.99	.395	.485	.115	.175	.22	.30	[illegible]	[illegible]	[illegible]
1912	.98	.345	.435	.121	.176	.22	.31	[illegible]	[illegible]	[illegible]
1913	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1914	1.11	.54	.69	.11	.256	.25	.432	[illegible]	[illegible]	[illegible]
1915	1.04	.54	.69	.11	.23	.245	.43	[illegible]	[illegible]	[illegible]
1916	1.00	.54	.69	.11	.16	.21	.284	[illegible]	[illegible]	[illegible]

THE 1917 MODEL PARSONS TRENCH EXCAVATOR.

Excavators, especially designed for light trenching for water works, irrigation, pipe lines, etc., are included in the new models placed on the market recently by the Parsons Co., Newton, Ia. These are shorter and very much lighter, but at the same time ruggedness has not been sacrificed. The new type excavator is built in four sizes as follows:

	Widths of cut.	Depth of cut.	Engine.	Weight.
Model 18	9"-12"-15"-18"	To 6 ft.	18 hp.	9,500 lb.
Model 24	12"-15"-18"-24"	To 10 ft.	28 hp.	15,500 lb
Model 36	18"-24"-30"-36"	To 15 ft.	45 hp.	26,000 lb.
Model 48	24" to 48"	To 18 ft.	70 hp.	48,000 lb.

There are a number of refinements of design in these machines such as ball bearing thrust bearings on the bevel and worm gears—new designs of buckets and side cutting attachments—conveyors mounted so as to be readily shifted from one side to the other; or on order, the machines may be built with double conveyors to deposit the material on both sides of the trench simultaneously. Operation of these machines, whether oil engine or steam, is reversible. Models 36 and 48 have power steering gear or hand steering gear as desired. Models 24 and 18 are steered by hand, and are equipped with automobile type front axle and steering gear.



Model 24, Parsons Trench Excavator.

The booms on all of these machines are built in sections which allows the machines to be adjusted to whatever maximum depths of trench will be found on any particular piece of work.

PERSONALS.

Effective this date C. F. Urbutt has been appointed track elevation engineer of the Chicago, Milwaukee & St. Paul Ry. at Chicago, vice C. H. Buford, assigned to duties in the Operating Department

Mark R. Lamb, South American Manager of Allis-Chalmers Co., is in Oruro, Bolivia, where he is collecting information on llama and burro transportation. He will be in New York and Chicago during April.

Peter Vandanacker has been appointed Chief Carpenter of the east end of the H. & D. Division of the Chicago, Milwaukee & St. Paul Ry. with office at Minneapolis, Minn., vice W. H. MacArthur, who has left the railway company's service.

W. F. Schaphorst, M. E., Advertising Engineer, and author of technical articles that have been published in Engineering and Contracting, has established an engineering advertising service office in the Woolworth Building, New York City.

The following changes in the engineering department of the city of Gary, Ind., have been made recently: H. E. Jordan transferred from Assistant City Engineer to Superintendent of Parks. O. B. Canaday promoted to Assistant Engineer. Ray D. Hammons transferred from Chief Draftsman to Assistant City Engineer.

Karl W. Gass, M. E., has resigned his position with Chester & Fleming, Consulting and Operating Engineers, Pittsburgh, Pa., to become a sales engineer with the Fort Pitt Engineering Co., Oliver Bldg., Pittsburgh, Pa., engaged in the design and erection of Stephens-Adamson Mfg. Co. transmission, conveying and screening machinery.

D. C. Wood has been appointed by the State Public Utilities Commission of Illinois as Acting Chief of the Service Division in the Engineering Department vice Stanley P. Farwell, resigned. Mr. Wood is a graduate of University of Illinois in the Electrical Engineer's Course and has been with the Commission, as Assistant Engineer, for nearly three years.

Harry R. Campbell, of Washington, Pa., has been appointed Statistician of the State Highway Department, to fill the vacancy caused by the resignation of W. R. D. Hall, who resigned March 15 to accept the position of Secretary of the Publicity Bureau of the Philadelphia Chamber of Commerce. Mr. Campbell at present holds the position of Clerk to the County Commissioners of Washington County.

W. P. Cottingham has been promoted to the position of city engineer of Gary, Ind., succeeding W. J. Fulton, who becomes President of the Board of Public Works. Mr. Cottingham has been assistant to Mr. Fulton during the past three years in charge of street and alley construction and maintenance. Prior to the engagement as assistant engineer in Gary Mr. Cottingham served as City Engineer for two years in Toppenish, Wash. He graduated as a Civil Engineer from the University of Minnesota.

Edward H. Thomas has been appointed Engineer of the Sugar Department of the J. G. White Management Corporation, New ork City. For the past three years Mr. Thomas was connected with the West India Management & Consultation Co. in the capacity of Chief Engineer, and, previously, was the Designer and Chief Engineer of the Sanborn Evaporator Co. Among the Sugar Centrals designed and built, or remodeled, under the direction of Mr. Thomas are Cupey, Punta Alegre and Alto Cedro, in Cuba; Consuela in Santo Domingo, Fortuna in Porto Rico, etc.

OBITUARIES.

Major Cassius E. Gillette, a well known consulting engineer, died March 18 at his home in Philadelphia, aged 57 years. Death was due to heart trouble from which he had suffered for several months. Major Gillette was graduated from West Point in 1884 and was assigned to the engineer corps of the army. His service time in the corps included a station in Ohio for five years on lock and canal work, a year in Chicago on General Miles's staff, six years in Savannah, Ga., four years in California and six months in Newport. He also saw service on the Isthmus of Panama, while in charge of the U. S. Engineer Office at Savannah. Major Gillette exposed the conspiracy to defraud the government in river and harbor work. A few years later he resigned from the corps to become chairman of a commission of engineers which investigated the contracts for the filtration plant and boulevards of Philadelphia. He was next appointed Chief of the Bureau of Filtration of Philadelphia at a salary of $17,000 a year and continued in this position until a new administration came into office. He then took up a consulting practice with offices in Philadelphia. He was chief engineer for a Philadelphia syndicate which undertook large mining and land development enterprises in Mexico, which were very prosperous until interfered with by the Mexican revolution. His most recent activity was investigating mines in Colorado. The illness which resulted in his death became serious while he was in that state and he was forced to return home.

INDUSTRIAL NOTES.

Walter L. Weeden, Worcester, Mass., has been appointed Field Secretary of the Granite Paving Block Manufacturers Association of Boston, Mass., succeeding Zenas W. Carter, who has been made commissioner of the publicity bureau of the Associated Metal Lath Manufacturers.

H. M. Lee, president of the Duplex Truck Co., of Lansing, Mich., announces that all preparations have been completed for the construction of a new factory buildiing 600 ft. long, 70 ft. wide and two stories high. It is expected that the new plant will be completed, machinery installed and manufacture of trucks started by Sept. 1.

Changes of personnel in the Stegeman Motor Car Co., Milwaukee, Wis., have been announced as follows: L. G. Schertl becomes Secretary-Treasurer and Sales Manager with Oscar Stegman remaining president and guiding head. F. W. Apel has been appointed Assistant Sales Manager. The directors include: Oscar Stegeman, President; Frank H. Parker, Vice-President; L. G. Schertl, Secretary-Treasurer, Frederick Gettelman, Faustin Prinz, Adam Mayer and C. P. Bossart. The company recently increased its capital stock from $100,000 to $200,000, and will have a new factory addition completed within a few days.

Announcement has been made by the Publicity Bureau of the Associated Metal Lath Manufacturers that their offices have been moved from Chicago to Room 901 Swetland Building, Cleveland, O., and that Zenas W. Carter, formerly of Boston, has been appointed Commissioner, to supervise all their publicity, promotion and investigation from the Cleveland office. Zenas W. Carter has been manager for manufacturers' associations for the past ten years, directing co-operative publicity and promotion work between manufacturers, distributors and consumers. He was the first General Secretary of the Electric Development Association when it was incorporated in New England, and he has managed the publicity and field promotion and investigation work of the Granite Paving Block Manufacturers' Association of the United States since their organization two and one-half years ago.

Statement of the Ownership, Management, Circulation, Etc., Required by the Act of Congress of August 24, 1912,

of ENGINEERING AND CONTRACTING, published every Wednesday at Chicago, Ill,, for April 1, 1917.

State of Illinois, County of Cook, ss.—Before me, a notary public in and for the state and county aforesaid, personally appeared H. P. Gillette, who, having been duly sworn according to law, deposes and says that he is the publisher of Engineering and Contracting, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in Section 443, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor and business manager are:

Publisher—Myron C. Clark Publishing Co., Chicago, Ill.
Editor—C. T. Murray, Chicago, Ill.
Managing Editor—H. P. Gillette, Chicago, Ill.
Business Manager—W. H. Fogerty, Chicago, Ill.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock): H. P. Gillette, Chicago, Ill.; N. M. Clark, Chicago, Ill.

3. That the known bondholders, mortgagees and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other securities are: (If there are none, so state.)—None.

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association or corporation has any interest direct or indirect in the said stock, bonds or other securities than as so stated by him.

(Signed) H. P. GILLETTE, Publisher.

Sworn to and subscribed before me this 24th day of March, 1917.

(Seal.) C. E. MENIDERS.

(My commission expires June 7, 1920.)

Dirt Mover and Pit Owner Issue
of

Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

First Wednesday Each Month............Roads and Streets......$1 Yearly
Second Wednesday Each Month, Waterworks and Hydraulics.......$1 Yearly
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Any Two or More Monthly Issues, 75 Cents Each Per Year

Contract News Appears in All Issues

Volume XLVII. CHICAGO, ILL., APRIL 18, 1917. Number 16.

THE CONSOLIDATION OF ENGINEERING NEWS AND ENGINEERING RECORD, AND A WORD IN MEMORY OF FROST AND WELLINGTON.

The consolidation of Engineering News and Engineering Record occurred April 5, following shortly after the death of George H. Frost, who started Engineering News in 1874 and remained in control of the paper until five years ago.

The new paper is called Engineering News-Record. Curiously enough each of the two papers had had five different names, and now they simultaneously are christened with a sixth name.

The editor of Engineering and Contracting, having been one of the editorial staff of Engineering News for two years, has always felt a keen and kindly interest in that excellent paper, and is glad to note that the News-Record will remain under the able editorship of Charles Whiting Baker, of the News.

The merger of the News and Record leaves Engineering and Contracting as the only other national weekly paper in the civil engineering and contracting field. Engineering and Contracting is itself a composite of four periodicals: Engineering-Contracting, Contract News, Engineering World and The Dirt Mover. "E. & C." has carried forward the volume numbering of the oldest of these four, Contract News, so that its present volume number is 47, indicating an age of more than 23 years.

Periodicals often have an individuality—unless they are mere imitations of something else—that enables a critical reader to name the periodical after merely seeing one of its editorials. This is a curious fact, particularly when it is considered that the editorials may be the work of several different men. Still more peculiar is the fact that even after the death of the chief editor, who impressed his personality upon the paper, his style usually persists for many years in the general editorial treatment, and often in the very phraseology of the articles. Perhaps the most striking example of this persistence of style is to be found on the editorial page of the New York Sun. Charles Dana has been dead a whole generation, but his biting irony and sardonic humor still live in the paper that he founded.

Mr. Frost, former proprietor of Engineering News, was not only an excellent writer, and a good judge of engineering literature, but a very astute business man. A civil engineer himself, he carried the entire load of editing his paper for many years, and at the same time directed its business policy. The struggle was long and severe, but he conquered. Mr. Frost had the "good fortune" (as the expression goes, but more probably it was his good discernment) to associate with himself as a partner one of the ablest engineering writers that ever lived—the late A. M. Wellington. Wellington, through his book on "The Economic Theory of Railway Location," had already given root to his fast growing reputation as a remarkable teacher of engineering economics. Had it not been that he confined his writings mainly to railway subjects, Wellington would probably have been more generally spoken of, with Frederick W. Taylor, among the great pioneer teachers of engineering economics. They that are well acquainted with the writings of both of these illustrious engineers find little to choose between them, either as to ability in expounding their themes, or as to the relative importance of the themes that they expounded.

Wellington's spirit still lived in Engineering News when the writer became one of its staff 15 years ago, but 10 years prior to that the writer had felt the power of Wellington's influence when first his celebrated book was read.

The engineering world owes a mighty debt to the two former proprietors and editors of Engineering News—Frost and Wellington.

THE LOW COST OF THE ROGERS PASS TUNNEL AND WHY.

The building of the longest railway tunnel on the American continent, and a double-track tunnel at that, for less than $150 per ft., inclusive of a concrete lining for 30 per cent of its length, is a record to be proud of. Bear in mind also that the work of driving this five-mile tunnel through hard rock (quartzite and schist) was completed six months ahead of the 3½-year time limit.

In our last Dirt Mover and Pit Owner Monthly issue we published a paper by Mr. A. C. Dennis, superintendent of Foley Bros., Welch & Stewart, the contractors for the Rogers Pass tunnel through the Selkirk Mountains on the Canadian Pacific, and in this issue we print a letter from Mr. Dennis relating to the cost of this tunnel. As above stated, the cost was $150 per ft. of double-track tunnel. This includes the contractor's profit of 10 per cent allowed on all expenditures. It includes lining 1½ miles of the tunnel with reinforced concrete. It includes the driving of nearly 4 miles of 7x8-ft. pioneer tunnel and cross-cuts to the main tunnel. It includes all preliminary costs, superintendence, etc. It includes liberal bonuses paid to the men, about which a word will be said later.

Since there were about 30 cu. yds. of excavation per lineal foot of double-track tunnel, the cost of $150 per lin. ft. is about $5 per cu. yd. of excavation. But this, be it remembered, includes concrete lining for 30 per cent of the tunnel length.

The highest record of progress on one heading of the Pioneer tunnel (7x8 ft.) was 922 ft. in one month. Part of this high speed is attributed to the use of "hammer drills," but excellent management and the payment of a bonus to the workmen account very largely for this record-breaking performance. In the main headings it was found that after the introduction of the payment of a bonus to the men for progress in excess of 450 ft. per month, nearly 25 per cent greater speed was secured. The men engaged in enlarging the headings were also paid a bonus, but in this part of the work the number of feet of hole drilled by each man constituted the basis for the bonus payment.

Summing up the reasons for the rapid progress and low cost of the Rogers Pass tunnel, they seem to us to be:

First, the method of tunneling, involving the driving of a pioneer tunnel off the line of the main tunnel.

Second, the excellent administration of the work.

Third, the payment of liberal bonuses to the workmen, which bonuses were adhered to.

Fourth, the use of hammer drills.

The Simplon tunnel through the Alps is nearly 12 miles long, and after 6½ years' work was finished in 1905, breaking all pre-existing speed records for hard-rock tunneling. The best month's record on a heading was 685 ft.

EFFICIENCY OF NIGHT WORK DEPENDENT ON ILLUMINATION.

It is generally agreed that night work is not as economic as day work where the work is done out of doors; but a thorough investigation of the reasons for the difference seems never to have been made. Consequently most contractors fight shy of night work, relying entirely upon the supposed truth of the generalization that it never pays except where work must be rushed to a finish.

The editor's own experience leads him to believe that there need be very little difference between the the output of the "owl shift" and the "eagle shift," provided two or three matters are given proper attention. The first of these is the matter of lighting. The second is the matter of warmth and food. The third is the matter of supervision and cost keeping.

Poor lighting not only retards progress because men can not work effectively in a twilight, but because it depresses the spirits of the workers. The mere fact that it is night has in itself no ill effect on the output of workmen, as the editor can attest from his experience in mining. The night shift in a mine is quite as efficient as the day shift.

Night work above ground is often cold work in the spring and autumn. It therefore pays to see that the men are well clothed and that bonfires or other means of warming up are provided. Also frequent feeding of the men and still more frequent passing of hot coffee among them has a surprising effect. But above all in importance is the lighting of the job. Here is where a penny saved is apt to be a dollar lost. In these days of cheap illumination there is no excuse for not flooding the work with light.

The Excavating Engineer states that the Illinois Koalin Co. operates a Bucyrus revolving shovel day and night digging clay, and that after a month's experience the night output has nearly equalled the day output. The illumination is furnished by 11 General Electric 500-candle-power flood lights. Nine of these are on poles 10 to 20 ft. high and can be adjusted to throw their rays in any desired direction. They give a strong light for about 2,000 ft. from the lamp. Two of the lights are non-focusing, for close range, and are suspended from cords so that they may be readily shifted, and thus give perfect lighting for the shovel work.

In this connection it is well to point out that the best type of electric light is the gas-filled tungsten lamp, for it consumes little more than half as much electricity per candle-power as the older vacuum tungsten lamp. Yet even the ordinary tungsten lamp is a cheap source of light. Thus a 500-candle-power tungsten requires about 0.6 kilowatt-hour of current per hour, or 6 K. W. H. per 10-hour shift.

GO INTO THE BUSINESS OF TILE DRAINING BY CONTRACT.

To contractors who are seeking new lines of work and to civil engineers who contemplate entering the contracting business we suggest a study of the prospects of making good profits in the tile drainage of farm lands. In the group of seven North Central States there are nearly 14,000,000 acres of land that is untillable because of the water that lies upon it and in it. But this is only "a starter" when one considers that many times fourteen million acres are under-productive because of excess of water in the soil during some part of the year. Tile drainage has ordinarily cost $10 to $20 an acre, but it has yielded an enormous profit on the investment, frequently repaying the entire cost in one season. Bear in mind, however, that practically all tile ditches have been dug by hand and that with a drainage excavator the cost of the ditching can be enormously reduced.

The editor has frequently seen one of these small excavators dig 2,000 ft. of tile ditch 3 ft. deep per day of 10 hours, two men operating the machine. But even where the daily average is only half or even one-third this output, the cost is so far below that of hand work as to make it foolish to consider hand work at all.

It should be remembered also that the kind of soil that most needs tile drainage is usually uniform in consistency and free from boulders. This insures continuity of work and freedom from breakdowns. We believe that the present time is peculiarly propitious for contractors to engage in tile drainage work. Farmers never were so prosperous; the demand for increased output of farms never was so great; labor never was more scarce.

Parson's "Land Drainage" is a book that serves to give an excellent insight into the problems of tile drainage. Gillette's "Handbook of Cost Data" gives detail costs of the ditching and the laying of tile. Lack of knowledge of how to do the work and what it costs to do it can not be pleaded as an excuse for failure to undertake this sort of work.

The manufacturers of ditching machinery publish not only catalogs on their machines, but booklets on farm drainage. The U. S. Department of Agriculture has bulletins on the subject, and the different State Agricultural Experimental Stations can furnish printed information. The back files of Engineering and Contracting contain a great many articles on tile drainage. Get busy on this wealth of data, you who have the ambition to make jobs for yourselves instead of waiting for others to make them for you. Get busy studying the methods and costs, and then go after the work.

A WAR CENSUS OF THE YALE ENGINEERING ASSOCIATION.

Richard T. Dana, secretary of the Yale Engineering Association, 15 William St., New York, on April 2 sent a circular to all members of that association, asking them to answer certain questions intended to disclose individual fitness for service to the government during the war.

The president of the association appointed a committee to prepare the questions. Believing that they will be of value to other engineering societies who are planning to make a "war census" of their members, we publish the list of questions in full:

(1) Name (2) Address. (3) Date of birth? (4) Place of birth? (5) Nationality? (6) American citizen? (7) Married? (8) Number of children? (9) How many persons depend on you for support? (10) Height? (11) Weight? (12) Physical condition, good, fair, poor? (13) Smoke? (14) Drink? (15) What is your present occupation? (16) What are your specific duties? (17) Do you own your business? (18) Are you on a salary (19) For what work are you best fitted by training and experience? (20) What degrees do you hold? (21) What foreign languages can you speak? (22) Understand? (23) Read? (24) What membership do you hold in eng. societies? (25) Are you experienced in handling men? (26) Can you ride? (32) Swim? (28) Shoot? (29) Sail a boat? (30) Navigate a ship? (31) Drive an automobile? (32) a motorcycle? (33) a locomotive? (34) a motor boat? (35) a marine steam engine? (36) an aeroplane? (37) Are you familiar with any of the following trades: Carpentry? (38) Steam fitting? (39) Blacksmithing? (40) Plumbing? (41) Surveying? (42) Drafting? (43) Machine tool operating? (44) Wiring? (45) Rigging? (46) Pattern making? (47) Moulding? (48) Boiler making? (49) Ship building? (50) Sheet metal working? (51) Marine engineering? (52) Machine shop management? (53) Manufacturing or installation of electrical equipment? (54) Power plant operation? (55) Naval ordnance? (56) Handling and storage of explosives? (57) Design of bridges? (58) Construction of buildings? 59 Streets? (60) Roads? (61) Sewers? (62) Water supply systems? (63) Water front improvements? (64) Ships? (65) Have you had experience in the care of the sick and wounded? (66) In compounding medicines? (67) In water supply analysis? (68) In chemistry? (69) Do you know shorthand? (70) Typewriting? (71) Signaling by wig-wag? (72) Semaphore? (73) Ardois? (74) Telegraphy? (75) Wireless? (76) Can you operate a telephone switchboard? (77) Do you own a horse? (78) a motor cycle? (79) an automobile? (80) a motor or steam boat? (81) Would you be willing to place such temporarily at the disposal of the government for quick movement of troops, etc.? (82) Are you now a member of any military organization subject to the call of the president? (83) Have you any application on file for a commission in the Army or Navy? (84) Are your qualifications listed elsewhere than here, and if so where? (85) Previous military service: Indicate number of years in Army. (86) Navy. (87) Marine Corps. (88) National Guard. (89) Branch of Infantry. (90) Cavalry. (91) Artillery. (92) Coast Artillery. (93) Engineer Corps. (94) Signal Corps. (95) Quarter Master Corps. (96) Do you

think your experience or training would entitle you to a commission? (97) If so, in what branch of the service? (98) Under your present circumstances would you be willing to enlist in the National Guard in the event of a general mobilization? (99) To go to sea? (100) To go to the front? (101) To accept a commission in an expeditionary force? (102) To perform military duty on the line communication (back from the front)? (103) To do consulting work for the government (gratis) without giving up your business? (104) If accepted for the Quarter Master Corps would your training especially qualify you for service in any of the following branches: Accounts and finance? (105) R. R. transportation? (106) Manufacturing? (107) Inspection of supplies? (108) Steamer transport service? (109) Executive duties? (110) If accepted for service and offered your choice what branch or line of endeavor would you choose? (111) What special qualifications do you possess for any particular branch of the service either as an officer or as an enlisted man? (112) What office or other equipment have you that might be available to the government? (113) Write letter stating business experience. Remarks.

THE AMOUNT OF KEROSENE OR GASOLENE REQUIRED TO DRIVE EXCAVATING MACHINERY.

When a gasoline engine is running continuously it consumes about one pint of gasoline per brake horsepower per hour. But engines used to drive steam shovels, dragline buckets and the like do not run continuously. There is very little printed information that gives the percentage of time that such an engine works at full capacity each shift.

The Excavating Engineer states that in stripping a limestone quarry for the Bethlehem Steel Co. a Bucyrus dragline (class 7), equipped with a 1-yd. bucket and 42-ft. boom, consumes 7 gals. of kerosene per hour. The machine is mounted on caterpillars and is driven by a 60-H. P., 4-cylinder gasoline engine. Hence, the engine uses but slightly less than 1 pt. of kerosene per horse-power hour.

In this connection it should be observed that while kerosene is somewhat less efficient than gasoline, gallon for gallon, it costs less than half the present price of gasoline and is therefore much cheaper for this sort of work. It is not so easy to start an engine driven by kerosene as one driven by gasoline, but this difficulty is overcome by running the engine on gasoline for about 15 minutes until it is thoroughly warmed. In cold weather a large engine is not easily started even after priming with gasolene. In such cases a very small quantity of ether in the cylinders will enable the operator to start the engine on the first quarter of a turn.

RAISING FOOD FOR CAMP USE.

Many a contractor has found it profitable to fatten pigs on kitchen waste. The Earth Mover suggests that it may be wise to go a step farther and raise the vegetables consumed at the camps. Why not?

A contractor friend of the editor used to advise every general contractor to do this very thing, and one thing more, namely, to raise hay and grain for his own stock. He did this successfully by renting farm land for the purpose. There is also a good deal of satisfaction in knowing that if a rain interferes with grading work it is benefiting the crop. So the contractor-farmer "gets 'em coming or going," even if not "coming and going."

In this connection we suggest the advisability of providing a small pumping outfit with which to irrigate the garden truck. Often a pump that is used to supply water for camp purposes can be used also to irrigate a garden. Remember that even in a so-called humid climate the rain has a habit of not running on schedule time, so that it never fails to pay well to irrigate vegetables.

If you do go into farming as a side issue, retain some good farmer as a consulting engineer to advise you what to do and when to do it. You will receive a handsome profit on money invested in such advice.

Charleston, W. Va., has been selected as the site of the new armor plate plant to be erected by the U. S. Government. The plant is to have a capacity of 20,000 tons per year and is to cost about $11,000,000. Work will start at once.

SHOULD ENGINEERING STUDENTS ENLIST FOR WAR?

In the first flush of war excitement many unwise plans are invariably proposed. Among these may be classed the suggestion that all college courses be discontinued, or, if not that, greatly abbreviated. But do we hear army or navy officers suggesting that West Point or Annapolis be forthwith closed to enable the entire student bodies to enter actively into war?

It is perfectly obvious that a half-baked military or naval officer, immature in training as well as in years, would be of insufficient value in active service to warrant his removal from his school. And, we ask, should it not be equally obvious that students in our engineering colleges should be encouraged to remain as students until the completion of their courses?

There are approximately 34,000 students of engineering and chemistry in our American colleges. Their ages are 18 to 24 years. Of corresponding age there are 6,000,000 young men in this country not studying engineering or science. In brief, for every college student of engineering and chemistry there are nearly 200 men of equal age who are not studying applied or pure science. Consider the significance of this ratio, and ask whether our engineering colleges should be broken up even in the slightest degree because a war confronts the nation.

This is pre-eminently a war in which applied science is the greatest factor. Indeed, it has been repeatedly called a war of engineers. Shall we utterly ignore the profound significance of this fact and cease training engineers when we most need to stimulate the output of this class of men?

The most difficult and probably the most important part of training received by the young men at Annapolis and West Point is their training as engineers. Those who graduate with the highest honors from West Point are made officers of the Corps of Engineers, U. S. A. This in itself serves to indicate what importance army officers themselves attach to engineering in warfare. And it should be remembered that, in so far as the engineering part of the course is concerned, the engineering taught at West Point does not differ appreciably from that taught in our civil engineering colleges.

As shown in detail in our issue of Aug. 16, 1916, there were 170,000 engineers, surveyors, draftsmen, architects and chemists in America in 1910, the architects numbering less than 17,000 and the chemists an equal number. This number of technically trained men in 1910 was almost double the number in 1900. It is safe to assume, therefore, that there are now about 250,000 technically trained men in America, of whom fully 200,000 are of military age. There are more than 20,000,000 men of military age, so that about one in every 100 may be classed as having some sort of technical training, but probably not more than half of these have had the equivalent of a four year's course in an engineering college.

One educated engineer to every 200 men of military age is not a high percentage, and it certainly should not be lowered, as it will be, unless engineering colleges continue to graduate their regular quota every year. Whether for war or for peace America needs more, not fewer, engineers per thousand of population. After graduation from high school at 18 or 19, four years of special education in methematics, economics and the sciences is meagre enough engineering education.

It has been said that a first-class gun pointer can not be trained in less time than two or three years. Surely it must be apparent even to non-technical men that four years is scarcely sufficient to give a thorough grounding in the principles of applied science. Therefore, it should not require much argument to convince governmental authorities that enlistment of undergraduate engineers for war should be discouraged.

We regard it as the duty of all engineers, but more particularly of those who are teaching engineering, to take prompt and aggressive steps to expose the folly of breaking up any of the classes in engineering colleges. The Society for the Promotion of Engineering Education should take the lead in preventing war fever from "striking in" and paralyzing technical educational institutions. Other engineering societies should also lose no time in taking similar action.

LAND CLEARING: AN OPPORTUNITY FOR CONTRACTORS.

Stumps, particularly the old pine stumps, always have stood in the way of the development of Northern Wisconsin. In this region there are over 7,500,000 acres of cut-over land that need only to be cleared to become as productive as the land in any other section of the state. Millions of acres of these rich fertile lands now unproductive would be worth at once from $60 to $80 per acre if made ready for cultivation. Clearing methods generally used by the settlers have been so slow, so costly and so laborious that little progress has been made. A great number of the land owners know almost nothing of modern methods of stump removal and a majority of the older farmers are unacquainted with the up-to-date labor, time and money saving devices for this kind of work.

Land clearing in Wisconsin offers an excellent opportunity for the contractor. In the past this has not always been so because the jobs were small and widely scattered. It is proposed now, however, to handle such improvements somewhat on the drainage district plan. Holdings will be consolidated into tracts of perhaps 1,000 acres or more and the clearing of this acreage let as one contract. Under this scheme, a contractor with the proper equipment, can engage in the business on a large scale. A considerable amount of clearing is now ready for letting. If any of our readers wish to take up this kind of work we will be glad to put them in touch with interested parties.

AN ENGINEER APPOINTED TO HEAD THE COMMITTEE ON NATIONAL FOOD SUPPLY.

Herbert C. Hoover, the engineer who has attained fame as chairman of the Belgian Relief Commission, is to be asked by the American Council of National Defense to become chairman of a committee on food supply and prices during the war.

The council expects so to co-ordinate production, transportation and distribution of food as to prevent food shortage and extortionate prices. Mr. Hoover has established a world-wide reputation as an executive through his handling of the great and complex problems of feeding millions of destitute Belgians. Because of this experience and of his knowledge of the methods adopted by European countries to conserve their food supplies, Mr. Hoover is pre-eminently fitted for the great task that will be his if the war lasts many months longer.

INTERPRETATION OF CONTRACT CLAUSES.

To the Editor: Referring to the letter published in your March 28th issue, page 293, on "Interpretation of Contract Clauses," I beg to submit the following comments:

The section first quoted seems to be the ordinary provision for liquidated damages, agreed upon by the parties as $50 per day. It is not understood what your correspondent has in mind when he says, "There are no references in any way in the contract to the foregoing clause." It is not clear to the writer why any other reference should be expected since the paragraph quoted seems to be complete in itself.

It is asked whether completion ahead of time implies or gives the contractor claim for a bonus since he is penalized on account of delay. In answer it may be stated that no bonus can be collected unless expressly provided for in the contract. It has been repeatedly held that while parties might agree upon or "liquidate" their damages in advance of construction, it was unlawful for them to agree upon a penalty. The reason for this is the reluctance on the part of the courts to enforce that part of an agreement which would prevent or preclude either party from going into court with his grievance. This action, it will be seen, would tend to oust the courts from the jurisdiction which they otherwise properly should have.

Your correspondent inquires whether a change in the site whereon the buildings were to be erected after work had been begun will operate to discharge the contract. It is said that the contractor acquiesced in the change and went ahead with the work, accepting a necessary extension of time.

It is clear that many terms of express agreements must frequently be extended by implication. Here, therefore, it is plain that the part of the original agreement referring to site or location was discharged by agreement; and even in the absence of any other specific agreement relative to the new location, still by their acts there is abundant grounds to establish a good implied contract in this particular. Since there seems to be no question as to the complete, or at least substantial, performance of all other parts of the contract, the answer is that the change has in no way invalidated the contractor's rights.

The bondsmen probably would not be released since, so far as shown, their contract referred to the erection of a particular type of building, etc., and contemplated the risks ordinarily inherent in such work, and this would not in the ordinary course of events be particularly different in one location or another. If, however, the responsibility of the bondsmen was substantially modified, it is plain that their contract of surety would be substantially vitiated.

With respect to the mistakes in plans, which is the plain effect of designating obsolete fittings, etc., it is a well established and necessary principle that the contractor does not and should not guarantee the accuracy of the design, or any parts thereof, unless he expressly accepts this responsibility. The whole basis of contract work is that the owner specifies what he wants and the contractor undertakes to furnish the thing specified. In such a case, therefore, the contractor is plainly entitled to any extra expense he may incur to rectify the plans and to furnish materials which are acceptable and equivalent to those which were presumably intended. It is very clear that the nature of his obligation does not include a guarantee of the accuracy of the plans accepted by him unless he expressly agrees to do so.

These points may be found discussed more fully in "Contracts in Engineering" (McGraw-Hill Book Company, New York, 1910), Sections 68 to 70, 80 to 82, 105, 109, 114, etc. Liquidated damages are treated in Section 131. Probably numerous court decisions can be found, though since these principles are so fundamental and well established, court decisions are now hardly necessary to reinforce them.

James I. Tucker,
LL.B. and Assoc. M., Am. Soc. C. E.,
Director School of Civil Engineering,
University of Oklahoma.

Norman, Okla.

THE COST OF THE ROGERS PASS TUNNEL.

To the Editor: I notice in your issue of Feb. 21 that you have the cost of the "Rogers Pass Tunnel" as $6,500,000. This is approximately correct for the total improvements, which include considerable line outside of the tunnel.

The tunnel proper for excavation, concreting and so forth, including contractor's profit, was below $150 per foot, which, being a double-track tunnel, compares very favorably with $180 per foot for the Great Northern single-track tunnel.

A. C. Dennis, Superintendent,
Foley Bros., Welch & Stewart.

Vancouver, B. C.

THE FIRST COUNTY MANAGER.

To the Editor: In the March 28 issue of Engineering and Contracting you ask "Who Will Be the First County Manager?" In answer I enclose a copy of the resolution adopted by the County Commissioners of Tillman County, Oklahoma, on Dec. 20, 1917, which created the office of County Manager and appointed the County Engineer to have charge of same.

For further information I am glad to state that the plan is working fine, and through it we have constructed more road in the last three months than has been built in the fifteen years before.

Pearl A. Little.

Frederick, Okla.

[The resolutions adopted by the Tillman County Commissioners follow.—Editor.]

Whereas, It is the opinion of the County Commissioners of Tillman County, Oklahoma, in meeting assembled this 20th day of December, 1916, that it is for the best interest for the County of Tillman and for the comfort and convenience of the citizens thereof that permanent and speedy construction of roads and bridges be encouraged.

Whereas, It is the opinion of the County Commissioners that the road and bridge business of Tillman County has grown to such voluminous proportions that it requires more attention than can be given by monthly meeting of the County Commissioners.

Whereas, The road construction requires careful and constant attention of some competent person.

Whereas, The road and bridge supervision requires a man of both technical and practical education.

Whereas, The maintenance should be performed in an efficient manner and at the proper time to accomplish the greatest returns for the money spent.

Whereas, In the construction of bridges and culverts and purchase of material and equipment many dollars can be saved the county by maintaining an office of county manager. Said county manager, under the direction of the County Commissioners, shall handle the affairs of all road and bridge work of the County of Tillman in a businesslike manner.

Whereas, An inventory should be made of material and equipment now on hand and an accounting system be instituted and records kept of all purchases and disbursements; now, therefore, be it

Resolved, That a man whose qualifications are such that he can design bridges, survey roads and keep a system of books which will serve as records be appointed county manager; and be it further

Resolved, That Pearl A. Little, county engineer, being competent and closely connected with the work, be and is hereby appointed to take charge of the office of county manager, with no additional salary more than that allowed for county engineer, except for necessary expenses incurred by reason of that office.

METHOD OF REMOVING PARTS FROM BOOM OF REVOLVING STEAM SHOVEL.

The following quick and simple method of removing the saddle block, gears, or other parts from the boom of a revolving shovel for the purpose of making repairs is described in the April Excavating Engineer by Mr. C. C. Miller.

First throw a heavy piece of chain, preferably a ⅞ in. switch chain, over the boom above the hoisting engine. Then raise the dipper until it is about 10 or 12 ft. above the bank. The two ends of the chain which has been thrown over the boom, are then hooked onto both arms of the dipper handle. Next take the top rollers out of the saddle block. This disconnects the saddle block. Then lower the bucket to the bank. As the saddle block has been disconnected the chains act as the bearing point and the ends of the arms are thus raised out of the saddle block.

A snatch block should then be made fast to the safety cable immediately over the shipper shaft. A ¾ in. or ⅝ in. cable should then be run through this snatch block to the hoisting drum. In order to allow for operating the snatch block, a sufficient length of hoisting rope should be run off the hoisting drum. The best way to do this is to run it off with the aid of a team or mule.

When the snatch block is rigged the saddle block may be hoisted up and dropped out of the way; then the thrusting gears and pinions. The repairing should, of course, be done on the ground. This method takes but a day and a half as a general rule, and requires a gang of but four men and a boss.

SOME 1917 PROBLEMS OF THE SAND AND GRAVEL PRODUCER.

The problems confronting the sand and gravel producer during the present year were outlined by Mr. E. Guy Sutton, General Manager Carmichael Gravel Co., Williamsport, Me., in a paper read March 15 before the Indiana Sand and Gravel Association. Quotations from Mr. Sutton's paper follow:

Last year our costs would have shown a greater increase had it not been that we had made favorable coal contracts and had laid in supplies and repairs early in the year before the abnormal advance in prices had been made. Then, too, the scarcity and independability of labor came gradually. This year we will encounter, to begin with, not only a shortage of laborers but also, on account of the great demand for men on the farm, in the factory, on the railroads and every other line of work, a spirit of independence, restlessness and discontent will exist resulting in inefficiency; labor will not only cost more, but it will be worth less.

Moreover, the best hope that the railroad officials give at the present time is that the car shortage will be as serious at the beginning of our operating season as it was at the close of last year. This opinion is supported by the following facts:

1. On account of the abnormal movement of freight, there is an actual shortage of cars suitable for shipping gravel.
2. Many cars are tied up by eastern embargoes.
3. New equipment cannot be secured as fast as wornout cars and locomotives are retired.
4. The railroads are short of motive power both for road hauling and switching at terminals, resulting in the slow movement of cars in transit and at destination.
5. Coal movements will continue in large quantities throughout the summer months because of the heavy demands of the railroads and factories; besides much domestic coal will be delivered to both dealers and consumers, and no doubt storage will begin early in the fall on account of the anticipated miner's strike after April 1, 1918.
6. Many coal cars are now being used for the transportation of high-class freight, due to the shortage of box cars.
7. The present ruling that cars must move in the direction of "home," if it remains in effect, will operate to increase the shortage aside from its other complicating features.

Moreover, this anticipated car shortage will not only effect outgoing shipments, but will delay deliveries of coal and other supplies used in the operation of the plant as well.

And so, considering only the car supply and the labor conditions, the situation does not appear bright, even to an optimist. But this is not all. You are already famliiar with the advances that have been made in prices from your own experience in purchasing supplies, repairs and equipment, so that a few examples of the rate of increase during the past year and a half will be sufficient to show the general trend with reference to prices of articles which enter into our cost of production: Nails have advanced 77 per cent, bolts 154 per cent, sheet steel 144 per cent, manganese parts 47 per cent, wire rope 40 per cent, belting 17 per cent, pipe fittings 62 per cent. Moreover, a reduction in quality has been made in many articles which is equivalent to an advance in price. It is a known fact that some manufacturers have resorted to this practice in order that ostensibly they may have the reputation of maintaining former prices. New equipment has not only advanced in price from 20 per cent to 100 per cent, but it is impossible to get reasonable deliveries of electric machines, boilers, steam shovels, locomotive cranes and industrial locomotives, all of which are prime requisites in the operation of most plants. This latter condition has placed second-hand equipment at a premium so that a used machine brings almost as much as new if it can be delivered promptly.

That the price of coal will range from $1.75 to $2.50 a ton at the mines, according to the grade, even for summer deliveries, is generally accepted. This is an advance in price of at least 100 per cent above what was paid last year.

Though it will be impossible to reckon with any degree of accuracy just how much our cost of production will be affected by the conditions which now beset us, yet it may be worth while to make some sort of calculations, even if they be based on facts and fancies in indeterminate proportions. In analyzing the operation statement for 1916 of a firm operating a representative gravel plant in Indiana the items of cost were found to obtain as indicated below:

Item.	Percentage of cost.	Estimated rate of increase. Per cent.	Percentage of increase.
Labor	32.1	25	8.0
Stripping	10.0	25	2.5
Fuel	10.4	100	10.4
Supplies and repairs	14.7	50	7.4
Expense	12.0	10	1.2
Royalty	2.8	...	....
Depreciation	5.3	...	....
Administration	12.7	5	.6
	100.0		30.1
Factor of safety			10.0
			40.1

Though there may be a divergence of opinion as to what the advance will be for each item of cost this year as compared with last year, yet that there will be a material increase no one will deny. The firm from whose records the above percentages were obtained has estimated that the rate of increase will be as indicated in the foregoing table whereby it is determined that the total cost of production will be approximately 30 per cent greater for 1917 than it was in 1916. Moreover, on account of the ever-changing situations which confront this country whereby we may be drawn into the whirlpool of disaster at any time, there exists an element of doubt as to how to proceed in our industrial world which is analogous to the troublesome hardpan and clay when it occurs irregularly and with indefinite extent in the pit. There is no intelligent way to solve this question of uncertainty, but that it must be considered in making estimates of cost is obvious. And so, arbitrarily we may add 10 per cent to our percentages already obtained, which might be termed a Factor of Safety.

The estimate of 40 per cent advance, which may have been obtained by a more or less illogical method, may be far from right. To be prepared to meet the anticipated raise and still make a legitimate profit is a question of more serious moment than to try to form an opinion as to how much more money we will spend this year than last year. There are three ways which if combined will allow us to meet this situation: (1) By practicing economy in every possible way; (2) by hearty co-operation among the members of this Association; (3) by advancing the selling price proportionate to the increase in cost.

METHOD OF HANDLING QUICKSAND IN DITCH EXCAVATION.

In widening and deepening an old drainage ditch, the contractors struck quicksand, making it necessary to devise ways for keeping the sand from washing and slipping over night into the excavated area. According to Leschen's Hercules, this was accomplished in the following manner:

The additional depth was from 3 ft. to 4 ft. and, in order to keep the depth, the contractors used a large canvas 12 ft. by 18 ft. with which the soil in the old part of the channel was staked down during stops.

This canvas had brass eyelets every 8 in. apart for fastening it to stakes, and when in position it would not only prevent slipping of the sand, but it also kept the soil from washing, as water ran over the canvas. The required bottom width of this ditch was 8 ft., but it was necessary at some points to make it from 12 to 14 ft. wide in order to get down to grade in quicksand pockets. The excavation was made with a turntable derrick equipped with a 1¼-yd. Haywood orange-peel bucket.

METHODS OF DIAMOND DRILLING AT MUSSEL SHOALS, TENNESSEE RIVER.

Careful sub-surface investigations were made for the proposed Federal lock and dam development at Mussel Shoals in the Tennessee River. Bids for an extensive system of diamond drilling were asked in June, 1914. The contract was awarded to Sprague & Henwood, Inc., Scranton, Pa., at the following bid:

Rock hole diamond drilling, 9,810 lin. ft., per lin. ft.	$3.25
Overburden hole, 2,330 lin. ft., per lin. ft.	3.25
Testing holes, per hole	5.00
Detailed retesting of leaky holes, 200 5-ft. lengths, per 5-ft. depth of portion of hole actually retested	2.00
Total	$40,430

The contractor was notified of the approval of the contract April 17, 1915, and on April 19 the first hole was started. Drilling at dam site No. 3 was finished Aug. 14 and at dam site No. 2 Sept. 4. The methods employed in the work are described by W. S. Winn, Assistant Engineer, U. S. Corps of Engineers, in the March-April Professional Memoirs, from which the following matter is taken:

Under the terms of their offer the contractors would have been required to put on 12 outfits; instead, 13 outfits were shipped to the job. While all of the outfits were not worked at any one time, it advanced the progress of the drilling to have extra machines on hand to replace those out of commission for repairs. Three of the drills were driven by steam and ten by gasoline. The steam outfits were used on the banks of the river, where they were accessible to coal, and gasoline was used for the drills in the stream and on islands. All of the machines were of standard size for taking 1⅛-in. core. They were manufactured in the contractor's own shops.

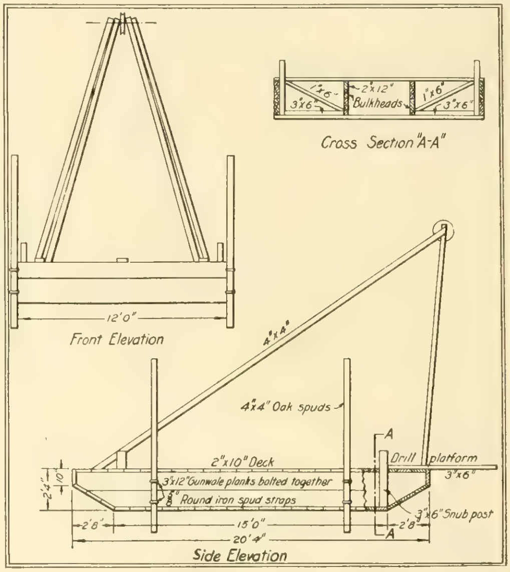


Fig. 1—Sketch of Drill Barge.

For drilling holes in the stream bed the gasoline drills were mounted on barges 2 ft. 4 in. by 12 ft. by 20 ft. 4 in. A sketch of one of these barges is given (Fig. 1), and is included for the purpose of showing with what simple, inexpensive floating plant the contractor was willing to undertake such a large job in a river of the size of the Tennessee, having swift currents and rock bottom.

The barges would have no salvage value at the end of the job and were built as cheap as possible, to stand the few months' service for which they were designed. They were built by the drill operators, none of whom were ship carpenters, and their kit of tools consisted of saws, hatchets and crude calking tools. A liberal coat of pitch served to render the calking efficient. The contractor stated that they cost about $100 each. Built by experienced carpenters, the cost should not have exceeded $70 each.

The weakest part seemed to be in the spud attachment to the hull, which consisted of two stirrups of ⅝-in. round iron to each spud. The spuds were raised by two men lifting with their hands. The barge was spudded up with the aid of a block and tackle, one block being attached to the top of the spud and the other to an eye-bolt in the deck. They were held in this position by the tackle and steadied by driving wedges between the spud and the barge gunwale.

The whole rig looked rather flimsy and failure was freely predicted, but the barges all came through the job in apparently good condition. Several of them had their forward ends shot out in blasting for casing holes, but they were so light they were easily pulled up on a rock and repaired. Their lightness was of advantage also in moving in the shallow water. They were often dragged over rocks having less depth of water over them than the draft of the barges.

A sketch of the pressure testing apparatus used is shown in Fig. 2.

Water to carry away the debris from the cutting edge of the drill in holes on land, was supplied by a small steam pump located on the river bank. In the holes drilled from barges a hand deck-pump, worked by one man, supplied the water.

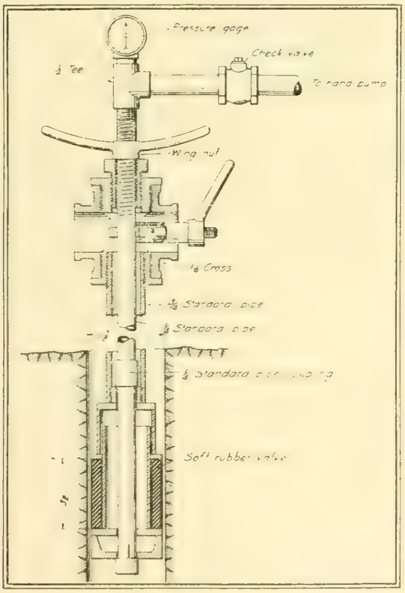


Fig. 2—Pressure Testing Apparatus.

The rest of the contractor's equipment was the usual assortment for outfits of the size used. A small rough board shack was built at each site for use as a diamond-setting shop and for storing extra parts, etc.

The specifications provided that a series of exploration holes, consisting of every fourth hole on the upstream line for each site, should first be driven. It was thought that this would show general conditions and develop unfavorable conditions, if any existed, that would necessitate a change of location, as provided for in paragraph 24 of the specifications. After this plan had been carried far enough to determine that no change of location would have to be made, the contractor was allowed to put down the holes in the order that best suited the arrangement of the plant. The machines were well distributed over the sites.

As the work progressed and results were so uniform, some of the holes on the downstream line at each site were omitted where the upstream hole of the pair had proven satisfactory. Some of the pressure tests were also omitted.

At dam site No. 2 five holes, about equally spaced across the stream, were driven to bottom elevation of 297, or 50 ft. lower than the deeper holes on the regular layout. This developed the strata for approximately 100 ft. beneath the river bed. At dam site No. 3 three such holes were driven to twice the ordinary depth.

Each line of holes was first marked on each bank with a stout hub. The holes were then approximately spaced along the line with a pliant wire cable. When a drill was set up for a hole it was accurrately located by triangulation from carefully measured bases on the islands and main shores.

Field notes were recorded on cross-section sheets, 16 by 21 in. The sheets were attached to light sketching boards with thumb tacks, and were carried to the field in waterproof bags. The notes in the field were recorded with pencil or fountain pen. When a hole was finished, the inspector who had charge of the hole transcribed his notes to a fresh sheet with a typewriter. This sheet is intended for a permanent record in the district engineer's office, hence all data noted on these field sheets were transcribed on the office sheets. The transcribed sheet was then sent to the Florence office, where a tracing was made of the diagram end of the sheet, and on it was placed everything of general interest. On the tracing the rate of progress of the drill is shown graphically. This eliminates a profusion of notes as to time of beginning, periods of delay, time required, etc., but gives all the information needed for a study of the chart.

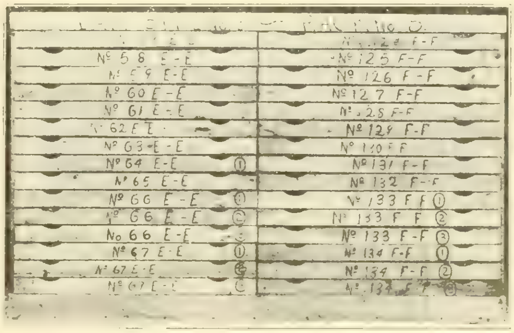


Fig. 3—Case for Diamond Drill Cores.

All of the cores were preserved intact and are stored where they can be inspected at any time. It is proposed to preserve them until the construction of the dam is well along toward completion.

For convenience in handling the boxes, they were made 3½ ft. long, inside measurement. Those for Dam No. 2 contained 15 core slots, and for Dam No. 3 10 core slots. One box, therefore, contained an ordinary core; for the deeper holes, two or more boxes were used. The full depth of the hole was represented by an equal length of core slot in its box. Where the core recovered was insufficient to fill its corresponding space in the core box, a wooden filler of the same diameter as the core was inserted. The wooden fillers, in this way, show the lack of core recovery for each pull. Elevations of bottom of each core pull were recorded in india ink on the adjacent partitions between core slots.

Since one of the chief reasons for preserving the core is that they may be inspected in the future, ready identification of a core and ease of access to it are desirable. To attain this, rough cases for receiving the core boxes were built. The core boxes were made like shallow drawers; as soon as one was filled it was marked and slipped into its proper place in a case. Each case has four sets of drawers, two sets pulling out on opposite faces. Each case contains sixty drawers, and five cases were required. Fig. 3 shows a filled case, which has the appearance of a chest of drawers. Instead of the usual plan of giving the box a flat bottom and separating the core slots with thin partition slats, the body of this box was made of 1⅞-in. boards, and the slots ploughed out with a wood-working machine. In this way a stiff box was secured and at a small cost. They were made in the shops at Muscle Shoals Canal, of cheap lumber, by low-priced men.

Figure 2 is a sketch of the device the contractor used for applying water pressure tests to the drill holes. The method followed was first to apply the pressure to the entire hole, the expandable washer being placed as near the top of the hole as practicable. If this test failed to meet the requirements of the specifications the tester was dropped 5 ft. lower in the hole, and pressure again applied, and so on to the bottom of the hole, or until the required pressure was secured. Tests of some of the holes in the downstream lines were omitted where the corresponding hole on the upstream line had proven satisfactory in both quality of core and pressure test. The method was somewhat varied in the deep holes on the left bank of Dam No. 2.

The first of these holes drilled was No. 48. In this hole a cavity was found at about river bed elevation. Naturally, no pressure test held above this cavity. It seemed desirable to know whether the strata above that elevation were watertight, so, in the remaining holes on the left bank, the procedure was to test in 20-ft. sections as the drilling advanced. This disclosed the fact that the seams between strata are remarkably tight. It is true that holes Nos. 46 and 96 showed low pressure tests, but this was on account of their nearness to the face of the bluff.

Some of the pressure tests seem to be slightly erratic. For instance, in hole No. 3 on the right bank, the pressure at elevation 420 ran down from 100 to 25 lb. in 60 seconds. For the next five detail tests it ran down to 15 lb., but for the next 5 feet below it held up to 95 lb. at the end of 60 seconds. There is no explanation to offer for this, except that the rubber washer may not have been absolutely tight in some of the tests and that the result was too small indicated pressures. The discrepancy is small, and attention is only called to it as one of the very few inconsistencies in the work.

Considering the severity of the tests, the results are considered rather remarkable. The water was pumped into the holes through a ¼-in. pipe. That by this means, and using a small steam pump, the pressure was brought to 100 lb. without trouble, was evidence that no leaks of consequence existed in the strata, and that in most instances some pressure was retained at the expiration of 60 seconds, shows that the foundations are practically impervious to water. A few drops of water leaking from a hole would have brought the pressure down immediately. In the deep holes in the river bed, it is believed that the shale underlying the harder measures, simply absorbed the water fast enough to reduce gage pressure. In every instance, the shallower holes adjacent to the deep holes give very satisfactory tests close to the river bed surface.

The maximum head on Dam No. 2 will be about 95 ft. A column of water 95 ft. high exerts a pressure of 41.2 lb. per square inch. The pressure therefore applied to the drill holes was about 2½ times that due to head above the dam. The same relation existed between applied pressure and pressure due to the proposed height of dam at dam site No. 3.

Great care was exercised to get correct results. The gages were frequently tested with a standardized gage at Lock No. 6, and all parts of the apparatus were watched during the tests.

It is believed that the percentage of core recovery compares favorably with the results obtained on similar work elsewhere. The recovery could have been increased both by drawing the core oftener and by taking a larger core, say 2 in. in diameter. The former was found to be true by experiment, and, judging by reports available on drilling operations at other places, it is the common experience that the oftener the core is pulled the greater the recovery. It was found that by pulling the core twice as often the core loss was cut almost in two. The core lost was simply ground up and washed out of the top of the casing. The grinding effect was shown in the con-shaped ends of some of the pieces of core. Vibration of the core barrel and drill rods broke the core into short lengths, which became more or less jammed in the barrel, causing breakage into still smaller pieces. A larger drill would have had less vibration in rods and core barrel, and the larger core would not have broken so easily. Still, for the purpose in view the results are considered very satisfactory. Below is given a table showing core recovery at each dam site.

	Dam No. 2.	Dam No. 3.
Number of holes	90	133
Total linear feet in rock	5,194	4,947
Aggregate length of cores recovered	4,591	4,003
Percentage of core recovery:		
Maximum	99.0	96.4
Minimum	73.0	52.4
Average	88.4	80.7
Seams:		
Numbers	100	58
Aggregate depth (feet)	22.94	18.33
Cavities:		
Number	12	3
Aggregate depth (feet)	24.85	25.86

No account was kept of the contractor's force until a drill was on the ground ready to be set up at a hole location. Following is a table showing force employed, man-days worked and rate of progress:

	Dam No. 2.	Dam No. 3.
Total time of diamond setters (man-days)	195	135
Total time of drill runners (man-days)	688	441
Total time of laborers and helpers (man-days)	1,462	1,077
Total linear feet drilled in rock	5,194	4,947
Total linear feet drilled in overburden	1,128	400
Aggregate depth of holes (feet)	6,322	5,347
Machine days worked	676	408
Average depth drilled per machine day	9.4	13.1
Total time (in 8-hour days) actual drilling	495	261
Average per day actual drilling time (feet)	12.8	20.5
Time lost moving drills, etc. (days)	181	147

The aggregate length of hole at both sites was 11,669 ft.

The average depth drilled per machine per day was 10.76 lin. ft. Since the price per linear foot was exactly the same ($3.25 per foot), and the rate of progress nearly so, for rock and overburden, both are combined in arriving at feet drilled per day. The maximum speed for short runs was 5.93 and 11.96 ft. per hour, and the minimum 0.14 and 0.61 of a foot per hour at Dams Nos. 2 and 3, respectively.

REDUCING MISFIRE COSTS.

It has been proven by actual experience and tests by U. S. Burau of Mines that it requires more and stronger explosives for submarine rock excavation than in open cut work. To a great extent delays and danger can be avoided by the proper selection and care in loading of explosives. Frozen explosives are less sensitive and efficient than when thawed.

In order to get the maximum out of any explosive it is well to use strong detonators.

For rock work before a steam shovel if work is wet it is best to use a low freezing gelatin from 40 per cent to 60 per cent strength depending on the character of the material. Present prices of glycerine being high, contractors are finding that good results can be obtained by using lower grade explosives where higher grades were formerly thought necessary. If work is dry a low freezing dynamite can be used. In tight hard bottom, the gelatin is best suited because in addition to the no-thawing advantage, it combines density with high water-resisting characteristics. Density is an advantage in that more weight of explosive can be concentrated in bottom of any given diameter of bore hole than with lighter dynamites.

For submarine rock blasting a 75 per cent strength gelatin dynamite is best adapted. Nothing weaker than a No. 8 electric blasting cap should be used with any gelatin. There is a lot of potential energy in a gelatin and in order to release it a No. 8 detonator is necessary.

Immigration in 1916.—The number of immigrant aliens admitted to the United States during 1916 was 355,767, an increase of 97,089 over the number for 1915. In January, 1917, the number admitted was 24,745. Of this total 3,139 were English, 2,405 South of Italy, 1,689 Scandinavian, and 1,258 Scotch.

THE USE AND ACTION OF EXPLOSIVES IN BLASTING WHITE PINE STUMPS AND PERFORMANCE OF EXPLOSIVES.

The tools and methods used in removing white pine stumps with dynamite under varying circumstances and the performance of explosives under different conditions are described in a thesis prepared by Morris Harry Wright of the University of Wisconsin. The thesis was written under the direction of Prof. Carl D. Livingston. It is based on information collected in the Second Land Clearing Special conducted by the Department of Agricultural Engineering, Wisconsin College of Agriculture, during September and October, 1916. The following notes are taken from Mr. Wright's thesis:

In blasting stumps conditions arise which require the use of different tools if the work is to be done to the best advantage. In most cases the quickest and easiest way to get a 1½-in. hole under a stump is to drill with a 1½-in. octagon steel bar about 4 ft. long, pointed at one end, using a 10-lb. sledge hammer. A hole 3 ft. deep can be made in a clay soil in about three minutes; in a sand and gravel soil it only requires about one minute to put down a 3-ft. hole. If the hole need be still deeper, a 1½-in. dirt auger is used. Extension parts are added with the depth of the hole desired. In a red clay soil it requires about three minutes to bore a hole 3 ft. deep, and in sand and gravel 2½ minutes. In tight dry clay soils it is sometimes easier to bore the holes rather than use the driving iron. A punch bar made of a piece of 1½-in. gas pipe about 5 ft. long with a "well point" welded into one end and a "T" on the other end, to which two short pieces of gas pipe are screwed for handles, is used to a very good advantage in locating the roots and determining the size and soundness of them when they are near the surface. In light soils or muck, holes can often be made with the punch bar quicker than with the auger or driving iron. In sandy soils it requires about 2 minutes to punch a hole 2 ft. deep and in clay about 3½ minutes.

In order to get the best results from a charge it must be properly tamped. Thus, a good tamping stick is a very important thing. It must be straight, smooth and strong if it is to pack the dirt properly in the hole. It must always be of wood. A pitchfork handle meets the requirements about as well as anything that can be obtained.

A round, pointed, short-handled shovel is another important tool to have on hand. Often it is necessary to get dirt for tamping holes from a distance. Again it may be required to fill up hollow spaces in the center and underneath stumps which have rotted or burned out if the full force of the explosion is to be obtained. If these cavities are not filled, part of the charge is wasted because the force of the explosion passes through these weaker channels.

There are several different grades of dynamite that should be used in the blasting of stumps, varying with the conditions. There are certain places where one grade is superior to all other grades. On the heavy red clays, silts and loams, or on wet, lighter soils, the 20 per cent or Red Cross Farm Powder is the grade of dynamite to use. This is a low-freezing dynamite, very safe to handle, and at present is about 3 ct. a pound cheaper than the 40 per cent Red Cross Extra which has been used almost universally until a short time ago. The 20 per cent will do just as good work, if not better, than the 40 per cent. This dynamite (40 per cent) is a trifle quicker acting and can be adopted and used on the light loam soils, which require a little quicker acting explosive than the 20 per cent. The 40 per cent Red Cross Extra is also a low-freezing dynamite. It is a quicker acting explosive than either the 30 per cent or 20 per cent, and is used to the best advantage on light, loose soils. On the very light and dry sands an explosive still quicker than the 40 per cent is needed. For this condition a 60 per cent straight nitroglycerine dynamite is best suited. This is a high-freezing dynamite, which is far more dangerous to handle, and which costs several cents a pound more than the other grades. Its general use for stumping is not to be recommended.

In working on different soils the charge must be placed high or low, depending on the nature of the ground. A sandy soil requires the holes to be placed deep, while a clay soil requires much shallower holes. The silt and loam soils fall in between the sand and clay. A sandy soil requires a quick-acting explosive, because in a sand there are many air voids between the soil particles which allow the gases to escape and weaken the force of the explosion. Unless a quick explosion takes place, a large part of it is wasted. In clay soils the particles are more compact and a slower and weaker explosive can be used. The silt and loams vary between the sand and clay and a medium-acting explosive is nearly always best suited.

The amount and kind of dynamite required to blast a 24-in. white pine stump completely out of the ground on a clay, a loam, and a sandy soil varies. On an average, a clay soil will require about 2 lb. of 20 per cent, a loam soil will require 3 lb. and a sandy soil will require nearly 4 lb. to do the same work. The same general comparison holds true with the other kinds of stumps. The size of the load of the different kinds varies, but vary relatively the same on different types of soil.

Different kinds of stumps have different kinds of root systems. The white pine stumps have massive lateral and semi-lateral roots. These roots are usually near the surface of the ground and run out several feet in all directions from the crown of the stump. The Norway pine has a semi-tap root system. There is one rather large root that runs straight down from the crown of the stump, with several fairly large roots which branch out in all directions. The hardwoods have a more fibrous root system, which is made up of a network of fibrous roots of different sizes, which often penetrate quite deep into the soil.

The white pine stumps rot very much slower than the hardwood stumps. Even after 20 or 30 years the white pine stumps are in a solid condition. On the surface they may appear to be unsound, but in from the surface about 1 in. a solid, well-preserved stump will generally be found. Sometimes the heart of the stumps has rotted, leaving a hollow core in the center surrounded by solid wood. The hardwoods rot very much faster. If the sprouts which come from the roots are kept down, in five or six years the fine, fibrous roots are decayed. There is then little left of the stump, and it can be blasted easily.

TABLE I—AMOUNT OF DIRT REQUIRED TO FILL STUMP HOLE.

Diameter white pine stump. Inches	Sand. Cu. ft.	Loam. Cu. ft.	Clay Cu. ft.
15	16	22	19
18	20	33	39
21	45	59	58
24	70	67	56
27	143	75	67
30	158	86	85

The amount of moisture in the soil plays a very important part in the blasting of stumps. If the soil is moist or saturated with water, the stump can be taken out with less dynamite, and a lower grade of dynamite can be used. When the soil is moist or saturated, the gases from the explosion cannot escape, and as a result the entire force of the explosion goes to lift the stump out of the ground. It is also much easier to make the hole for the charge when the soil is moist or wet. On a sandy soil quite moist the low grades will do satisfactory work, but when the soil becomes dry, the higher grades must be used to do the work.

The size of the hole left after the stump is blasted is important. The hole left by the same kind of stumps on different types of soil is different in shape and depth. The white pine on a sandy soil usually leaves a hole that is shaped similar to a cone. It is wide at the top and gradually tapers to a point at the bottom. The heavy loams leave a U-shaped hole that is not as deep or as tapering as the hole left in the sand. The clays leave more of a rectangular shaped hole. It is the shallowest of all three holes. The amount of dirt in cubic feet to fill the holes under white pine stumps of different diameters on different soils can be found in Table I. In measuring the hole the diameter and the depth of the cone-shaped cavity were averaged so that the resulting cylinder would contain the same volume. The following formula was used: Diameter squared times .7854 times the depth equals the capacity of the hole.

Various kinds of dynamite act in a very different manner with changes of temperature. There are, in general, two classes, a high and low freezing dynamite. The high-freezing dynamites are very apt to start to freeze and become insensitive at about 50° F., while the low-freezing dynamites are much more resistant to lower temperatures. There appears to be no definite point at which any one grade will freeze.

To determine the sensitiveness of different grades of dynamite at different temperatures a series of tests were made. A stick of dynamite was cut in two equal parts. In one half was placed a No. 6 electric cap, the other half being placed a certain known distance from it. Both were wrapped in a paper tube to break the air currents between the two pieces. The cap was detonated. If the second half remained unexploded, the trial was repeated, but in this case the unprimed half stick was moved nearer until both half sticks were detonated by the same cap. In this manner the different action of each grade of dynamite was noted and recorded in Table II.

TABLE II—DETONATION DISTANCE IN INCHES

Temperature.	20%	30%	40% Red Cross Ex.	60% Red Cross Str.	60% straight nitro-glycerine.
60 F.	4	3	12	18	20
47 F.	2	2	10	12	18
33 F	2	3	6	4	2

A second series of tests (Table III) were made to determine if there was a difference in the detonating power of a cap due to its position relative to the dynamite. In one case a No. 6 electric cap was placed at right angles and in another series of tests parallel to a stick of dynamite. Three different grades were tested. Successive caps were exploded and moved nearer until the dynamite was detonated. A piece of paper was folded so that it covered both the cap and stick of dynamite. It was weighted down at the edges with sand to shut off the air currents. The temperature was 45° F.

TABLE III.

Grade	Detonation distance at Right angles Inches.	and Parallel. Inches
20 per cent	3	2
30 per cent	2½	1
40 per cent	2	1

A series of tests were made to see if there was any difference in the distance that one cap would detonate another cap due to relative positions of the caps. They were tested at right angles and parallel. Caps were placed known distances apart and one of the caps detonated. If this cap failed to detonate the other cap, the trial was repeated with the caps being placed nearer to each other until a distance was found where both would be detonated. The results obtained are recorded in Table IV.

TABLE IV.

Temperature.	Detonation distance at Right angles Inches.	and Parallel Inches
70 F.	13	10
8 F.	4	½

REPLACING BROKEN U-BOLT IN A STEAM SHOVEL.

The method described below is reprinted from the April Excavating Engineer. First shove the slide plate out of the way, along the dipper handle. If the yoke or saddle block has fallen to the ground, hoist it up by rope and set it on the gears. Drop the new U-bolt over the shaft. Then take a 2x6-in. timber about 10 ft. long and put it over the engines and under the shaft. With a chain hook pull the U-bolt around the shaft until the ends stick up; meanwhile put a man on the upper end of the timber and hold the U-bolt in place. Then pick up the yoke and slide plate and drop them over the U-bolt; this will require two or three men—the pit crew and cranesman may be called up. If the threads on the U-bolt have not been injured, this operation should take but 20 to 30 minutes.

GRADING METHODS AND COSTS IN EARTH ROAD CONSTRUCTION.

The grading, usually, is by far the largest item of work connected with earth road construction. The most economical methods and machinery to employ in grading a particular road depend on the character and amount of the work to be done. In a recently issued bulletin of the U. S. Department of Agriculture on "Earth, Sand, Clay and Gravel Roads," the methods and equipment employed in the construction of earth roads are outlined and considerable data on labor, organization and costs are given. The bulletin was prepared by Charles H. Moorefield, senior highway engineer, U. S. Office of Public Roads, and that portion relating to grading methods is given in abstract below.

Where the grade and cross section of the road follow closely the original ground surface, most of the necessary grading usually may be done with a grading machine. In the case of embankments, built up with material from borrow pits along the sides of the road, an elevating grader frequently may be used to advantage. If material must be moved longitudinally along the road from cuts to fills in order to bring the surface of the road to the required grade, the work usually must be done either with scrapers or dump wagons. Where a considerable volume of material is to be excavated in a relatively short distance a small steam shovel with dump-wagon equipment sometimes may be employed economically. Each of these methods may best be described separately.

Use of Grading Machine.—Some of the best makes of grading machines are provided with attachments for such purposes as shifting the frame back and forth on the rear axle so as to adjust the blade to a desired position with reference to the wheel tracks, or to lean the wheels at an angle with the vertical and thus lessen the tendency of the machine to slide over a bank, or to cut the rear wheels at an angle with the frame in order to overcome the tendency to slide when the blade is loaded. Most of the better makes of such machines are now constructed so the blade may be reversed entirely and the convex surface used for smoothing a road surface after it has been graded approximately to the required cross section. Machines of this type are made in different sizes and weights and cost from about $175 to $300 f. o. b. factory. The heavier sizes are best adapted for construction work and the lighter ones for maintenance.

A modified form of grading machine consists of a blade similar to that of the machine just described, which is supported by a simple frame on only two wheels. The 2-wheeled machine usually weighs only about one-fourth as much as the 4-wheeled type and costs considerably less, but the 4-wheeled type generally is to be preferred on account of its greater stability and also because it can be adjusted to meet a much wider range of conditions. In the following description of the method of operation, therefore, it will be assumed that a 4-wheeled machine is to be used.

To operate a grading machine successfully where the work is moderately heavy requires at least six horses, while for light maintenance work after the road is graded four horses usually are sufficient. For satisfactory work the team must be accustomed to working together and must be under complete control of the driver. To break in a green team ordinarily requires two or three days of relatively very light work under favorable conditions and with a capable driver. Poorly trained teams and improper driving have been responsible for more unsatisfactory and uneconomical grading-machine work than any other one cause.

Before any machine work is done the area to be graded should be either burned or mowed over so as to remove all grass and weeds. The grading then should proceed as follows:

(1) Set a row of stakes, 100 or 200 ft. apart, along the inside edge of each side ditch. The purpose of these stakes is simply to aid the driver in making the initial furrow of the machine conform with the line of the road,

and since the stakes are destroyed by the first furrow they need be only sufficient to serve this temporary purpose.

(2) Set the blade of the grading machine at an angle of about 30 degrees with the road, so that the material loosened by the cutting point of the blade will be moved in toward the center of the road; also lower the cutting point and raise the heel, so that the blade will plow an initial furrow about 6 in. deep and about 18 in. wide. Then make the initial trip with the point of the blade cutting about 18 in. outside of the stake line and the outside rear wheel of the machine against the face of the furrow. The material loosened by the first furrow then will escape under the blade in a ridge just inside the stake line.

(3) Readjust the machine so that when the outside horses follow the initial furrow in making the second trip the blade will cut a new furrow of somewhat less width than the first and the outside rear wheel will follow the face of the new furrow. Then make successive trips with the machine adjusted in this way until the outside edge of the side ditch is approached, except that after each two trips it is well to rest the team by readjusting the blade and pushing the loosened material over toward the center of the road. For this latter work the blade may be set at a greater angle with the road, and the heel should be lowered and the point raised, so that the cutting edge will conform closely to the crown of the road while the machine is in operation.

(4) Repeat the above described operation, omitting the stakes and beginning about 18 in. farther from the center each time, until the side ditches are excavated to the required depth and the road is approximately to the required cross section.

(5) Bring the outside faces of the side ditches to a uniform slope by making one or two trips of the machine with two wheels, one front and one rear, on the bank and the cutting edge of the blade against the slope.

(6) Make several trips over the road, cleaning out the ditches and smoothing up the surfaces. The last few trips should be made with the blade reversed, as this method tends to produce a better compacted surface. But, in any event, it is necessary that during the first few months after the grading is completed the road surface should be kept smooth while it is being compacted under traffic. To do this may require frequent use of the grading machine or the drag.

The method of operating a grading machine described above necessarily will have to be modified at times in order to meet special conditions. Where, for example, the ditch area is covered with heavy sod or contains a number of large roots, it may be very desirable to plow this area and cut the roots with an ax before using the grading machine. If this is done the plow furrows should be turned toward the center of the road and the line of the initial furrows should be controlled by two rows of stakes as described above. If the sod is very tenacious it should be harrowed with a disk harrow ahead of the grading machine, and after the material has been moved over toward the center of the road the lumps of sod should be thrown out. A method sometimes followed is to skim off the sod, by means of hand shovels, ahead of the grading machine, but this method is expensive and seldom justified.

Whether or not it is necessary to contend with any considerable quantity of sod, the use of a disk harrow usually will prove helpful in securing a smooth uniform road surface with the grading machine. In general it is sufficient to give the loosened material a thorough harrowing after the road has been brought approximately to its required shape, but before the final shaping is done.

Where continuous long stretches of road are to be graded with grading machines, it frequently is economical to substitute a traction engine for the teams and to employ two machines. Where this is done the first machine is connected immediately behind the tractor, either directly behind or to one side, as the conditions require, and the second machine is connected behind and to one side of the first. Otherwise the method of operation is not essentially different from that already described.

The rate at which a road can be graded up with a grading machine varies to a great extent, and depends largely on the character of the soil. Where the original cross section of the ground is approximately level, and the soil conditions not unfavorable, a grading machine drawn by six well-trained horses should cut out the side ditches and shape the road in from 20 to 35 round trips. Allowing for a reasonable amount of lost time, the rate at which the team travels should average from 1½ to 2 miles per hour, and under the circumstances assumed above, the length of road graded per day should average not less than one-fourth mile. Such favorable conditions seldom are found for any considerable stretch of road, except in the prairie section of the Middle West, and the average rate of grading with a grading machine is, therefore, much less than one-fourth mile of road per day.

Use of Elevating Grader.—The essential features of this machine are a plow with a heavy moldboard, an elevating belt, a suitable frame for supporting the plow and belt, and driving and adjusting mechanisms for operating the belt and controlling the work. The plow loosens the material and throws it onto the belt, which conveys and deposits it either in the roadbed or wagons.

Elevating graders are adapted especially to building up embankments with material excavated from shallow borrow ditches along each side of the road. They also may be used to advantage in excavating long, shallow, through cuts and loading the material thus excavated into wagons for use in building up embankments at other points. The latter use, however, is restricted to situations where there is sufficient space to operate the grader and at the same time afford passageway for the teams and wagons to follow under the end of the belt to receive the successive loads as the grader is drawn forward.

It is customary to employ a traction engine for operating the elevating grader, though teams are used sometimes. Ordinarily, the machine may be operated successfully either with a 25-H. P. tractor or with 12 well-trained horses. A well constructed elevating grader, adapted to either horse or tractor power, may be purchased at an average price of about $900.

The rate at which earth can be excavated with an elevating grader is relatively very high when conditions are favorable and the grader can be kept moving. But there are a number of rather complicated parts about such a machine which sometimes get out of order, and the work also is hampered frequently by many unforeseen contingencies, such as "bogging" of the wheels, choking of the plow or the elevator belt, occurrence of buried stumps or stones in the excavation, etc. For these reasons the actual capacity of elevating graders, considered over a long period, seldom is more than about one-third or one-half the rated capacity, and where the material is loaded into wagons as it is excavated the actual capacity of the machine may be reduced still further. Elevating graders of the size used ordinarily in road work have a rated capacity of about 100 cu. yds. per hour.

Use of Scrapers, Wagons, Etc.—To grade a road of any considerable length, no matter where it is located, usually will require a considerable amount of work with devices other than the grading machine and elevating grader. The latter machines, as previously explained, may be very economical for special conditions to which they are adapted. But these special conditions seldom prevail for more than comparatively short stretches of road without sections intervening which require that a relatively large volume of material be moved from excavation to embankment within a distance of only a few hundred feet.

The choice of proper implements to employ in moving material from excavation to embankment depends, first, on the nature and quantity of the material to be moved, and, second, on the length of haul. In general, where the material consists of earth it is loosened with plows and the economical method of hauling is fixed by the haul length about as follows:

For lengths of haul not exceeding 150 ft., drag scrapers;

for lengths of haul between 150 ft. and 600 ft., wheeled scrapers; for lengths of haul above 600 ft., wagons. Where the material consists of solid rock it must be loosened by drilling and blasting and practically always is hauled in wagons or carts, regardless of the haul length.

The two types of plows commonly used in road grading are the turn plow and the rooter plow. The former is the type generally used for loosening ordinary soils, while the latter is used for breaking up hardpan, old road surfaces and other earth unusually difficult to loosen. Either type is drawn by four horses, or in some cases by a traction engine, and is operated by three men, including the driver. Plows of the first type average about 150 lb. in weight and sell at an average price of from $12 to $18, but heavier plows of this type range in cost up to about $30. With average soil conditions they may be made to turn a furrow about 7 or 8 in. deep and from 8 to 10 in. wide. The hardpan plows vary considerably in weight and selling price, but cost more than the turn plows. One reason for the higher cost is that the points must be made of a very high grade of steel in order to be durable.

Drag scrapers are made in 1-horse, 1½-horse and 2-horse sizes, which have respective rated capacities of 3, 5 and 7 cu. ft. Drag scrapers have an average weight, when empty, of from 75 to 100 lb., and an actual capacity of about three-fourths the rated capacity. The price, f. o. b. factory, averages about from $4 to $6 per scraper.

In operating drag scrapers the drivers also may load and empty the scraper, but frequently it is economical to provide additional laborers for this purpose. With a haul length of 100 ft. and the teams moving steadily, one laborer should be able to load or empty and spread the material for about three scrapers. For scraper work to be effective the material to be excavated must be thoroughly loosened by the plows and should be free from large roots or stones. Where such obstructions occur time is saved by having them removed by hand during the progress of the plowing.

The average small organization for carrying on road grading work with drag scrapers is made up about as follows:

Force:
1 foreman.
4 to 6 scraper drivers.
2 laborers for loading scrapers.
2 laborers for dumping and spreading.
1 driver for plow.
1 laborer to hold plow.
1 laborer for trimming shoulders, etc.
*4 to 6 two-horse teams for scrapers.
1 or 2 two-horse teams for plow.
Total, 1 foreman, 14 laborers, and 7 teams.

Tools:
6 drag scrapers (capacity 5 cubic feet).
1 road plow.
2 picks.
2 axes.
2 mattocks.
3 shovels.

*Where necessary, one of the scraper teams may be used to help the plow team.

The force employed should vary somewhat with the haul length, which is usually between 25 ft. and 150 ft. Under average conditions an organization such as that described above should move from 300 to 350 cu. yd. of earth per 10-hour day.

An objectionable feature of drag-scraper work is that the embankments tend to settle very irregularly. The reason is that the successive loads are not spread out uniformly as they are dumped, but are deposited as a succession of rather compact cores with the intervening spaces consisting of comparatively loose material. The loose material settles more than the compacted spots, and this unequal settlement produces pockets in the surface which hold water and gradually become deepened under the action of traffic. Where the material to be moved is loose and light, such as the prairie soils of the Middle West, this objection can be overcome largely by substituting Fresno or Buck scrapers for the common type of drag scrapers.

Fresno scrapers are made in several different sizes and range in capacity from about 8 to 12 cu. ft. They are drawn usually by three or four horses, and can be operated in almost as small a space as drag scrapers. Their average cost is from $15 to $20 each. One principal advantage of Fresno scrapers is that the runners may be adjusted to spread out the load to any desired depth from 2 or 3 in. up to 12 in. and this better distribution of the material in the embankment tends to prevent inequalities from developing in the finished road surface.

Wheeler scrapers are used to a greater extent in road grading than either drag scrapers or wagons. The reason for this is that in road work the haul length falls, more frequently than otherwise, within the limits for which wheeled scrapers are economical. Several different sizes of such scrapers are in ordinary use, but the size employed most commonly has an actual load capacity of from 11 to 15 cu. ft., according to how heavily the load is heaped. Scrapers of this size ordinarily sell for from $35 to $50 f. o. b. factory.

In operating wheeled scrapers the material is loosened by plowing, in the manner already described, and is loaded by the scooping action of the scraper. Two horses usually are sufficient to draw the scraper after it is loaded, but a second team, called a snatch team, is hitched in at the front of the tongue to assist in loading. The snatch team should consist of either two or three horses, according to the character of the material, and one snatch team should serve several scrapers. The loading and dumping of the scrapers are done by laborers provided for that purpose and not by the drivers.

A small organization for carrying on grading work with wheeled scrapers may be made up about as given below:

Force:
1 foreman.
6 to 11 drivers.
1 laborer for plowing.
2 laborers for loading scrapers.
2 laborers for dumping and spreading.
1 laborer to trim slopes, etc.
1 two-horse team for plow.
4 to 8 two-horse teams for scrapers.
1 or 2 two-horse snatch teams.
Total, 1 foreman, 17 laborers, 11 teams.

Tools:
8 wheeled scrapers (capacity 11 to 15 cu. ft.).
1 road plow.
2 picks.
2 mattocks.
2 axes.
3 shovels.

The force employed should vary with the haul length, usually from 150 ft. to 600 ft. Six to eight scrapers should be employed where the haul exceeds 250 ft. Where necessary, one of the snatch teams may be used to assist the plow team.

Such an outfit should move from 200 to 250 cu. yd. of earth per 10-hour day.

Several types of dump wagons are used in road-grading work. Probably the most common is the ordinary farm wagon fitted with a slat-bottomed bed. The most usual capacity for wagons of this kind is about 1¼ cu. yd. Patent dump wagons are made in sizes ranging from 1 to 3 cu. yd. capacity, and, in general, are preferable to the slat-bottomed wagons, because they are turned around more easily in a short space and are much more easily dumped. Patent dump wagons of the size employed ordinarily in road work (1½ cu. yd. capacity) sell at an average price of about $150, f. o. b. factory. One-horse carts are used sometimes instead of wagons, but two-wheeled vehicles are very severe on horses, especially when hauling over rough ground, and therefore the use of carts is not recommended.

Where wagons are used for hauling and the excavation is fairly light, it is customary and economical to loosen the material with plows and to load it into the wagons with hand shovels. If the excavation is fairly heavy and sufficient in amount to warrant the additional outlay, it is economical sometimes to employ a small steam shovel for loosening and loading the material. The steam shovels used ordinarily in road work have a dipper capacity of from ½ to ¾ cu. yd. Under fairly favorable conditions steam shovels of these sizes can be made to load from 400 to 500 cu. yd. of stiff earth per 10-hour day.

Where the material is loosened by means of plows and hauled in wagons the average small grading gang may consist of 1 foreman, 3 laborers and 2 teams for plowing, 9 laborers for loading, 2 laborers for spreading and a sufficient number of teams for hauling to keep the above force busy. With such a force the number of wagons for maximum efficiency varies from about 3 for a 500-ft. haul up to about 12 for a haul of 1 mile. Ordinarily, one of the plow teams may be employed in hauling for at least a part of the time.

Under average conditions such a force as that described above should move about 150 cu. yd. of earth per 10-hour day.

Finishing the Surface.—No matter how the grading of an earth road may be accomplished, it usually is economical to bring the road surface to its final shape by means of a grading machine. In making excavations it is not generally considered practical to form the crown and side ditches with scrapers or hand tools alone, and the cross section is, therefore, frequently left approximately flat. The grading machine is then used, in the manner already described, to produce the required cross section.

Construction Costs.—In the following statements and data an effort is made to show the approximate range of cost rather than the average.

The following data (Tables I and II) are intended to furnish a rough guide in making estimates of grading cost at a flat rate per cubic yard. They are based on labor at 15 ct. per hour; horses at 12½ ct. per hour. The depreciation of grading equipment and repairs are figured at 5 per cent per month while in use, and it is expected that the force will be organized economically and managed efficiently.

TABLE I—GRADING MACHINE WORK.

Assumed conditions: Original cross section flat; team to consist of six to eight well-trained horses; no material moved longitudinally.

Character of soil.	Cost per mile.
Light prairie, free from stumps, roots, etc.	\$ 60 to \$ 80
Average clay loam	100 to 150
Heavy clay, moderate amount of sod and roots, plowing necessary throughout	200 to 250
Heavy clay, exceptionally difficult conditions	From \$250 up
Crowning and shaping road which has been graded with scrapers, etc.	50 to 75

TABLE II—EXCAVATION AND EMBANKMENT.

Assumed conditions: All material to be loosened with plows or by blasting, and to be moderately dry when handled. Hauling to be done by means of drag scrapers, wheeled scrapers, or wagons.

Kind of material.	Average haul length. Feet.	Method of hauling	Average cost per cubic yard. Cents.	Remarks.
Light sandy loam, free from roots, etc.	50	Drag scrapers	10 to 15	Material assumed to be such that little or no plowing is necessary.
	100	Drag scrapers	12 to 20	
	300	Wheeled scrapers	16 to 25	
	1,000	Wagons	25 to 40	
Average clay loam, free from roots, etc.	50	Drag scrapers	15 to 20	Material such as to be loosened with plow drawn by two horses.
	100	Drag scrapers	17 to 25	
	300	Wheeled scrapers	23 to 35	
	1,000	Wagons	32 to 50	
Heavy clay.	50	Drag scrapers	18 to 25	Four horses required for plowing.
	100	Drag scrapers	21 to 30	
	300	Wheeled scrapers	28 to 38	
	1,000	Wagons	40 to 55	
Hard pan or loose rock.	300	Wagons	40 to 65	Low prices apply where material may be loosened with 4 horses and hardpan plow. High prices where blasting is necessary.
	1,000	Wagons	45 to 75	
Solid rock.	300	Wagons	\$0.65 to \$1.50	High prices apply where stone is hard and excavation shallow.
	1,000	Wagons	.75 to 1.75	

Prevention of Malaria on Construction Jobs.—The track crews and bridge gangs of the Illinois Central R. R., when working in malarial districts are given quinine during the mosquito season. The foremen give the men two 5-grain quinine capsules on Wednesday night and again on Saturday night. It is stated that this method has reduced malaria among the men 90 per cent. In one bad terminal surrounded by swamps the method was given a good trial. Not one case of malaria developed in 18 months in the crews working under the foreman at this point.

The lower branch of the State Legislature of Illinois on April 12 passed the Meents bill, proposing a referendum on the question of issuing \$60,000,000 worth of bonds to build a 400-mile system of hard roads in Illinois. The vote was 109 to 6. A companion bill, proposing a 50 per cent increase in automobile licenses January 1, 1918, and another 50 per cent increase two years later, was passed, 94 to 1.

GRAVEL AND SAND PLANT WITHOUT BIN STORAGE.

A gravel and sand plant without bin storage, except for small hoppers which hold only enough to allow for shifting of cars, was constructed recently for the Western Indiana Gravel Co. The plant, in effect, uses railroad cars instead of bins. The installation has a daily output of 2,500 cu. yd. in 10 hours, and is located at Lafayette, Ind.

The material is excavated by a steam shovel, loaded into trains of side dump cars, and thrown into a large hopper, from which an automatic feeder delivers it at a uniform rate to a 30-in. belt conveyor. This belt discharges the material into a triple-jacketed revolving screen of 5 ft. inside diameter which separates the bank run into sand and three grades of gravel, the over size going to a No. 6 McCulley crusher.

The crushed stone enters an elevator which has 27 in. wide by 14 in. projection continuous buckets made of 3/16-in. steel and mounted between two strands of 18-in. pitch steel bar roller chain, having ⅜-in. by 3½-in. side bars and 6-in. single-flanged rollers with case-hardened bushings at each articulation point. The stone is carried up about 60 ft. in this elevator and discharged into a second triple-jacketed screen whose inner cylinder is 4 ft. in diameter. Here the several sizes of crushed stone are separated with the stone dust eliminated and the oversize going to a 36-in. Symons disc crusher to be re-elevated and re-screened by the same equipment.

Screening Plant and Crusher House.

All material is thoroughly washed, a 10-in. Erie centrifugal pump furnishing between 2,000 and 3,000 gal. per minute to long spray pipes extending the entire length of both screens. The dirty water from the gravel screen carries the sand with it to a settling tank where clean sand is produced. The washing water is successfully used over and over, only about 10 per cent make-up water being required. This is accomplished by the use of a large reservoir, into one end of which the dirt-laden water from both screens is sluiced and allowed to settle and clean itself while clean water is being pumped from the other end. This continues until the one end is filled up with sediment, a process which requires several years according to the experience of the operators, but whenever it becomes necessary the filled-up end is dredged out and the intake and outlet ends of the reservoir reversed, the newly dredged portion now serving as the former.

The building which houses the crushing and screening operations is of steel construction throughout and enclosed in a galvanized corrugated steel housing with large sliding doors on the main and second floors. Above the doors are steel cantilever beams to which block and tackle or hoists may be attached. There is a steel trolley over both crushers and practically every unit is controlled by an independent motor. A combined blacksmith and machine shop is maintained at the plant for handling quick repairs and alterations. The plans were worked out by the officers of Western Indiana Gravel Co., in collaboration with the engineers of the Webster Mfg. Co., Tiffin, O., who designed, furnished and erected all of the steel work and machinery with the exceptions noted above.

NEW DESIGN OF AUTOMATIC AIR DUMP CAR.

A new design in automatic air dump cars, which eliminates necessity for individual reservoirs on the cars, has been built recently by the Orenstein-Arthur Koppel Co., Koppel, Pa. The illustrations show cars of the "Mesabi" type built by the above company for use at the Sellers and Morris Mines of the Oliver Iron Mining Co. and also in construction for the Eveleth Mines.

The cars are operated by compressed air from pump and operating valves located in the locomotive. The cars may be operated from the locomotive cab or individually from each car and may be dumped all to one side or part on one side and part on the other.

The body of each car is held in its normal load-carrying position by a locking device and supported in this position by bolsters which securely hold the body in four places. When air is admitted to the cylinder for dumping, the first few inches of travel of the piston releases the locking device on one side of the car, completely releasing that side and the further travel of the piston dumps the body.

Automatic Air-Operated Dump Cars of the Mesabi Type.

There are two dumping cylinders located in the middle of each car, one on each side of the center-sill, each exceptionally large in diameter and mounted to give a large leverage. A feature particularly distinctive is the automatic air cut-off controlled entirely by the movement of the body. In the Koppel design when the body is heaped to one side, or when other conditions make the dumping very easy, very little air is required to operate this car, and cases have been noted wherein the car has dumped and the air shut off before the piston made one-half its travel. The saving in air thus afforded eliminates the necessity for individual air reservoirs on the cars.

Another marked feature is the simplicity of the locking device in the absence of small working parts. This locking device projects outside the body bolsters, where it is open to easy inspection and free from danger of becoming inoperative because of snow, ice, dirt, etc. All valves are standard Westinghouse plug cocks, proof against freezing weather, and possibility of accidental dumping from leaky valves is eliminated through a construction which holds the cylinder cocks wide open at all times when the bodies are in normal load-carrying position.

METHOD OF SPRINGING BLAST HOLES AT THE SANTA RITA MINES OF THE CHINO COPPER CO.

Large quantities of explosives are used by the Chino Copper Co. in its copper ore mining operations in the Santa Rita District, New Mexico. The following description of the methods employed by this company in springing blast holes in rock is taken from a recent bulletin of the U. S. Bureau of Mines.

Before the drill holes are loaded and blasted, one or more small charges are exploded in the bottom of each, to make an enlarged chamber for the final charge. The object is to make so large a chamber at the bottom of the hole that the charge may be concentrated into so compact a mass that none of it will fail to detonate, and that the explosive energy may be concentrated where it will give the maximum effect. The springing eliminates any water that may be in the hole, but it generally increases the liability of an inflow of water by shattering and fissuring the surrounding rock. If granulated powder can be forced into these fissured places the effectiveness of the blast is greatly increased.

Where the rock to be broken is relatively soft and weak, and the drill holes not more than, say, 30 ft. deep and not over a third of that distance back from the face of a steam-shovel cut, one springing is usually all that is necessary. Where the rock is hard and tough, or where the holes are very deep, as many as four successive springing charges may be required before a chamber large enough for the final blasting charge is made. After each successive springing the hole must be cooled off, generally with water, before another charge is introduced.

Both before and after springing the drill holes are sounded by a specially constructed plummet (see Fig. 1). This is a billet of hard wood about 30 in. long and having a metal weight in the lower end. This springing gage is attached to a rope and lowered into the hole. By tilting it from side to side while the lower end rests on the bottom, the experienced powderman can estimate the size of the hole. With this gage he also measures the depth of water in the hole. A small hand mirror is at times very useful for reflecting light into the hole, thus enabling inspection of the upper 10 to 30 ft.

The procedure in springing holes is somewhat as follows: The powderman lowers the springing gage into the hole and notes its size and depth, the depth of water, etc. He then drops in the springing charge and again lowers the gage to determine whether the charge has reached the bottom. A fuse, passed diagonally through a stick of dynamite about 2 in. from one end, extends along the side of the stick to the other end, into which the end containing the detonator is inserted about 2½ in. This stick of dynamite, with cap and fuse attached, is called a primer. The fuse is then lighted and the primer is dropped or lowered into the charged hole, followed by a hurried lowering of the gage to show whether the primer has reached the bottom. After this 2 to 4 gal. of water is poured in as "stemming," the gage is quickly withdrawn, and the powder man retreats to a safe distance. After the detonation the gage is again lowered and the size of the chamber estimated. If necessary, other springing charges are used, each about twice as large as the preceding one, until the hole is sufficiently widened or chambered out at the base to receive a proper blasting charge. For the third springing, where the holes are over 30 ft. deep, and often for the second springing if much water is present, electric detonation is used. Where there are several holes to be fired simultaneously electricity is employed instead of fuse.

The blasting squad usually consists of a powder man and four helpers.

The powder man places all explosives in the drill holes, except in the springing of short holes, when the work may be done by the assistant powder man. The helpers carry the explosives and accessories to the powder man while he is gaging the hole and charging it.

The amount of the charge for each hole varies according to the toughness of the rock, the position of the hole with relation to the face and to other holes, and its depth and extent of chambering. The drill holes to be blasted are "bank holes"—those drilled vertically on each bench and situated back approximately one-third of their depth from the edge of the bench—and "toe holes"—those driven into the face of the bench, say, 4 to 6 ft. above the shovel level at the foot of the bench. The toe holes are driven with a downward slope of 20° to 30° below the horizontal.

When the holes are sufficiently chambered or sprung and are ready for loading, an electric-detonator primer is carefully lowered to the bottom of the hole. The first part of the charge, varying from 100 to 300 lbs., is dropped in after it. Another primer is then placed in the hole and the remainder of the charge, 75 to 250 lbs., is added. During the process of loading, the powder man frequently drops in his gage, to determine how rapidly the hole is filling and to guard against the clogging of the powder. Often granulated Trojan powder is poured in to fill the interstices between the sticks of dynamite and the fissured places in the rock. Thus air spaces are minimized and the efficiency of the blast greatly increased. When the charge is all placed, screened clayey sand and loam are carefully shoveled into the hole and packed down for stemming.

ADJUSTABLE FLAT SURFACE SAND SCREEN.

Adjustable flat surface screens, as shown in the accompanying illustration, are used by the Diamond Sand & Gravel Co. of Bedford, O., for screening the sand from the pit as it is loaded into the railway cars. This portable screen makes it possible to load a car in 30 minutes. Before the screen was installed, when customers specified certain sizes, it often required the labor of two men for one day to screen one car load by hand. These screens have been used by the above company for the past 7 or 8 years and have given excellent satisfaction.

Sand Screen Used at Pit of Diamond Sand & Gravel Co.

Bids were opened April 3 by the Department of City Transit of Philadelphia, Pa., for three contracts for the Broad St. subway. The Keystone State Construction Co., Philadelphia, at $2,815,000 and $3,336,000 was low bidder on Contracts 103 and 204, and the Philadelphia Subway Construction Co., Philadelphia, at $2,885,000 was low bidder on Contract 104.

METHODS OF USING DYNAMITE IN DIGGING POLE HOLES.

Where poles must be set in rock, dynamite has long been used in making the holes, and this method is being quite largely adopted by contractors and construction foremen for nearly all sorts of soils except in easily worked sand and loam. The following outline of the methods employed in this work is taken from recently issued publicity matter of the Du Pont Powder Co.:

Trials in different soils have shown that what is a good loading practice for one condition does not always hold true for others, and it is necessary to shoot a few holes in order to arrive at a correct loading.

Better results have been obtained by removing the top earth to a depth of several inches and to the diameter of the pole hole desired before making the bore hole for the dynamite. This has the effect of relieving the pressure and diminishing the formation of the bridge over the cavity. In making the holes for the dynamite a punch bar driven by hammers, a soil auger with a long handle, or a churn drill are generally used, although one large telephone company uses a specially made hollow pipe drill that is churned up and down, doing very effective work in clay soils, enough water being used to make a thin mud.

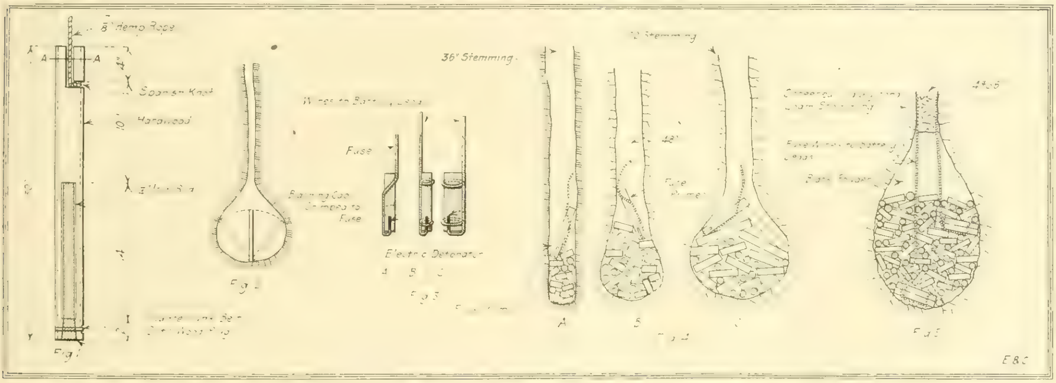


Fig. 1—Springing Gage. Fig. 2—Method of Using Springing Gage. Fig. 3—Fuses for Springing Holes. Fig. 4—Successive Changes. Fig. 5—Final Change.

For deeper work up to 6½ ft., very good holes are made by tying small pieces of from ⅛ to ½ cartridge to a small straight lath or stick, starting at the bottom end and spacing them about 6 to 12 ins. apart, leaving the last piece about 18 to 24 ins. below the top of the ground. This distributes the charge along the entire hole and packs the earth tightly against the sides, leaving a cavity from 12 to 18 ins. in diameter. Sometimes the dynamite is inserted into a long roll or cylinder of heavy stiff paper and held in place by sticking pins through it, or by cutting short sticks the length it is desired to space the cartridges apart and dropping them alternately into the hole with the cartridges. Care should always be taken not to allow earth to fall into and close the hole between the cartridges, for this has a tendency to break the detonating wave from one cartridge to another, and may result in misfires.

Ordinarily no tamping is necessary, but for harder material a small amount of tamping has the effect of confining the gases formed in the explosion and forcing them to do more work laterally. Tamping generally leaves a bridge over the cavity. By varying the size of the cartridges, the spacing apart along the hole, and the amount of tamping, in a few trial holes the engineer is able to obtain a system of loading to fit almost any condition.

For a pole line constructed through a district where the soil was hard clay, very slightly moist, the following loading gave excellent results for 4½ ft. holes: ⅓ cartridge in bottom; ⅓ cartridge 12 ins. above; and ⅓ cartridge 12 ins. further up; no tamping.

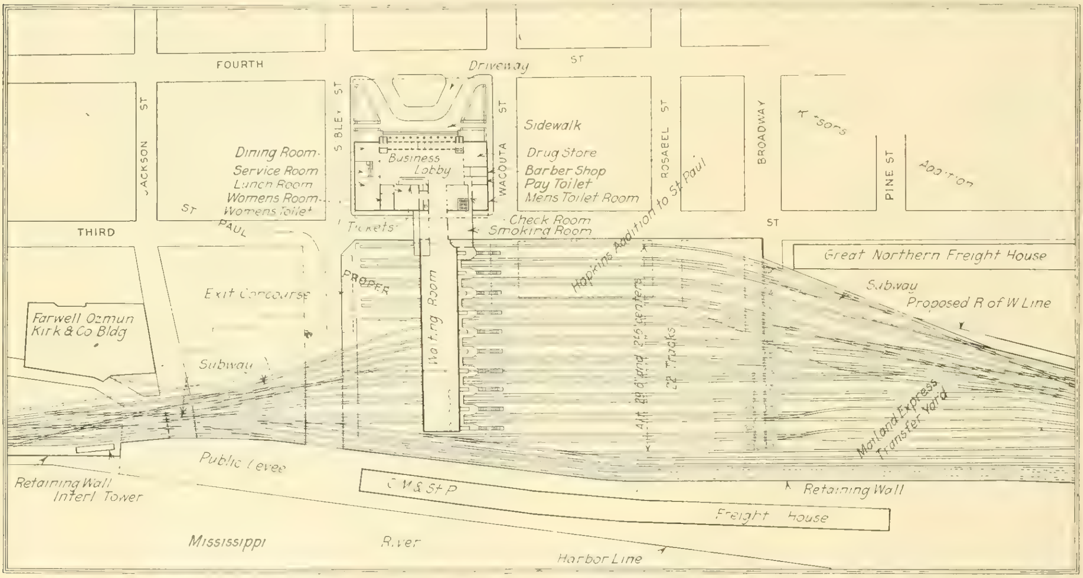
In another section, the soil was a heavy, plastic, water-saturated clay and holes 6 ft. deep were wanted for large poles. The best loading in this case was found to be seven ¼ cartridges spaced 6 in. apart.

In general, the quicker acting dynamites make better holes than the slower acting, heaving grades, a 40 per cent to 50 per cent straight grade being used in summer and a 40 per cent to 60 per cent low-freezing extra being used in winter when there is some liability of the dynamite becoming chilled or frozen.

THE NEW PASSENGER TERMINAL AT ST. PAUL, MINN.

Plans were announced last week for the new passenger terminal at St. Paul, Minn. The improvement will require an expenditure of several million dollars and will involve much excavation, filling and concrete work. The station layout and a portion of the new trackage is shown in the accompanying illustration.

The new terminal will occupy the site of the old union depot, which was burned in 1913, but will extend through to 4th st. and to Wacouta st. The present union depot trackage is 8½ miles, and the 14 tracks in the station yard have an available trackage of 12,459 lin. ft. The new terminal will provide for 27,200 lin. ft. of station yard tracks. The total mileage of tracks will be 12.35. The shortest station yard track will be 800 ft. in length, and the longest 1,800 ft. in length. There will be 22 passenger tracks and 2 freight tracks. There will be 11 passenger platforms, the aggregate length being 10,800 ft.



Station Layout and Portion of Trackage for New Passenger Terminal of St. Paul Union Depot Company.

The head house will be 150 ft. by 300 ft. in size and the waiting room will be 80 by 400 ft. The baggage, mail and express rooms under the track will have an area of 200,000 sq. ft. Twenty-seven elevators for baggage, mail or express will be installed.

The illustration shows the main plan of the head house. There will be one floor above this containing offices, private rooms for women and the kitchen facilities. Below the main floor there will be two basement floors for station facilities, emigrant quarters and for the U. S. Post Office. The new track will be at an elevation of about 16 to 18 ft. above the present tracks. Subways will be constructed at various streets. Retaining walls will be erected along the right of way.

The terminal will be constructed by the St. Paul Union Depot Co., of which W. C. Armstrong is chief engineer. Charles F. Frost, Chicago, Ill., is the architect.

PILE DRIVING HINTS.

Interesting examples of pile driving methods employed to meet unusual conditions are contained in the committee report submitted at the last annual convention of the American Railway Bridge and Building Association. The following notes on the subject are quoted from the recently issued proceedings of the convention:

On certain parts of the Canadian Northern Ry. deep muskegs are encountered, the grade line of the railway being but a few feet above the surface of the muskeg. Piles longer than the driver leads are often required in these places. Sometimes the piles are raised and dropped vertically, outside of the leads, several times until sufficient penetration is obtained to allow them to go under the hammer. At other times sufficient penetration can not be obtained in the above manner, and it is then necessary to lash a tapering timber to the side of the pile. Light blows of the hammer are applied to this timber until the pile will go under the hammer and regular driving can proceed. A deep and rather soft clay also has been encountered. This is too deep for the point of the pile to reach firm bottom even though splicing of piles may be resorted to. In such cases timbers are bolted on, giving a horizontal cross section of the pile resembling a Maltese cross. This enlarges the surface of the pile in contact with the clay and has given satisfactory results when used with discretion.

On busy lines on the Chicago, Milwaukee & St. Paul a very limited time is allowed drivers between trains. These troubles have, in certain cases, been remedied by the use of telephone communication between the pile driver and the train despatcher.

Where trestles are being re-driven on the Chicago, St. Paul, Minneapolis & Omaha Ry. a practice is made of moving the piles to the driver with a team where ground conditions will permit, and by rafting them where there is open water. This has been found to be economical as it saves the expense and time of moving the work train back to the end of the trestle to pick up piles.

On the Delaware, Lackawanna & Western Ry., where pockets of gravel and strata of hard pan are encountered, it is a rule to stop driving instead of driving through to softer material which a test may indicate is present.

In September, 1915, the Detroit & Mackinac Ry. renewed the piles and caps in a trestle, where the chord was practically new, by pulling the new bents to place after the old ones had been cut out, and without moving or cutting the chord.

On part of the southern division of the Gulf, Colorado & Santa Fe Ry. which is located in a semi-arid region in western Texas, ground is often encountered which is hard to drive through on account of the baking which it receives during long drouths. To meet this condition excavations about 2 ft. deep are made for the piles holes, which are filled with water and allowed to stand over night. In this way the penetration required is more easily reached. In the same territory a chalky limestone is encountered in which driving is greatly aided by first springing with dynamite and then flooding the holes with water. After this is done it is possible to secure penetration of 24 to 26 ft.

At some points on the Illinois Central Ry. hard pan and shale are encountered close to the surface, making it necessary to use cast points on hard wood piles to prevent brooming. There have been cases where false-work piles without shoes were driven into shale and it has been found, when pulling them, that the bottoms were broomed 2 ft. or more.

It is the experience of the Kansas City, Mexico & Orient Ry. that in nearly all cases piles drive and carry their load better when not sharpened, and especially so when the penetration is slight and the piles land on rock.

On the New York Central (Lines West) it has sometimes been necessary to drive piles for falsework which struck solid rock at an elevation above the bottom of the excavation. In these cases, the piles were generally pointed with large, square points so they would stand firmly on the rock under traffic until they could be excavated and replaced with frame bents. At other places where driving has been extremely soft and very long piles would be needed to give sufficient penetration to stand firmly under loads, 40-ft. soft wood piles have been driven down to the rail and 30 to 35-ft. oak piles spliced on top of them, and the driving continued, thus obtaining the equivalent of piles from 70 to 75 ft. long. One bridge driven entirely in this way has carried safely for 20 years without further penetration or settlement of the piles under traffic.

HANDY EXTRAS FOR A STEAM SHOVEL.

There are two pieces of equipment, states the April Excavating Engineer, that every contractor using medium or heavy excavating machinery will find a very good investment to have on hand. The first is a good chain block of from one to two tons capacity which can be used in numerous ways. Around a steam shovel it has many applications in the reeling of cable or the picking up of heavy parts when making repairs. It can also be used in connection with the rolling stock for guiding cars into place, when dump cars are off the track, in straightening out a kink in the track between the trucks of a shovel and in many other cases.

The other piece of equipment consists of at least one powerful jack, the size depending somewhat on the maximum weight of the machine on which it may have to be used. The experience of many erecting engineers in putting up different classes of machinery under every kind of condition has shown that a good easy-running ratchet screw jack is better for this class of work than the hydraulic jack, as there is less to get out of order and it is much more likely to operate properly when suddenly needed. Where railroad type shovels are used, one jack of 25 or 50 tons capacity, depending on the size of shovel, will often help out in many ways. In the case of big draglines or coal stripping shovels, two jacks of this size or perhaps one of 75 tons capacity will often save their price during one or two calls for their use. Two jacks are particularly serviceable where the machine has to be erected a number of times.

Examples of the usefulness of both the jack and the chain block are innumerable. In taking a shaft out of a gear, for instance, the jack may be used for pushing and the block for pulling. On coal stripping shovels it sometimes happens that a rail will break under one of the trucks; a 75-ton jack will save much time and money, as it is sufficiently powerful to lift up one corner of the truck and permit the replacing of the rail.

For general contract use, a jack without a self-lowering feature is usually fast enough and is recommended because of its lower cost.

LOCOMOTIVE CRANES FACILITATE RENEWAL OF BRIDGE TIES.

Locomotive cranes are used by the Lehigh Valley R. R. to expedite the renewal of ties on bridges. A description of the methods of handling this work is given by E. R. Wenner, supervisor bridges and buildings in the proceedings of the recent annual convention of the American Railway Bridge and Building Association, from which the following notes are taken.

At Towanda, Pa., the Lehigh Valley has a double-track deck plate girder bridge, 1,808 ft. long, consisting of 13 spans, with a maximum height of 45 ft. from the base of rail to the bottom of the stream. The east-bound track, known as track No. 1, has 1,532 8 in. by 12 in. by 12 ft. creosoted ties, some with an elevation of as much as 5 in., as the bridge is on a curve. The renewal of these ties was handled in the following manner:

All of the ties were framed at the site of the bridge which is located in the yard at headquarters. Slots were cut across the framed spots to allow for rivet heads in order that no framing of any kind need be done while the ties were being placed except for some rivet heads on gusset plates. As they were framed the ties were placed in piles of two tiers each and seven ties high, in numerical order, in such a way that when the ties were thrown over, one to the left and another to the right, they would fall in proper order ready for placing. The ties were loaded on cars with a locomotive crane by placing a chain around each pile as it was loaded and they were unloaded on the bridge in the same manner, handling the piles in proper order.

On the day before the ties were to be placed, all wooden guard stringers and clip bolts were removed from the bridge, and the tops of the girders between the ties were cleaned and painted. On the day the ties were placed, the trains were operated over a single track, using a motor car with a train crew to pilot them. The work was done with 3 locomotive cranes with operators, 1 engine and crew, 2 general foremen, 2 carpenter foremen, 24 carpenters, 1 painter foreman, 20 painters, 1 general track foreman, 3 track foremen, 80 track men, 1 signal man and 1 pilot crew.

The track was opened at 6 A. M. and one locomotive crane with half of the men started at each end of the bridge taking out the old ties and placing new ones. Each locomotive crane had behind it a car of new ties ready to place. Fourteen old ties were bunched up and lifted from the bridge at each operation and loaded on cars on the opposite track which were handled by the engine and the third locomotive crane between trains. As the old ties were lifted out, the painters cleaned and painted the tops of the girders, after which a pile of 14 new ties was lifted from the car behind the crane and put in place. This operation was repeated by the crews at both ends of the bridge until all of the 1,532 new ties were placed, the track laid, the ties plated and full spiked and the iron guard rail placed. The time consumed for this work was 12 hours. The ties and elevation blocks contained 160,612 ft. B. M. of timber.

The above method of handling the work was considered a great improvement over the old method of placing ties without the use of locomotive cranes. It effected a great saving in expense and reduced the annoyance of interference with traffic to a minimum. The men were so placed for this work that each man had his particular duty to perform and all operations had been carefully planned out in advance. Everything was carried out as planned in a very satisfactory manner.

Since the above work was done, the Lehigh Valley has used the same method of renewing ties on several other bridges with equally satisfactory results. One was the renewal of ties on Bridge No. 206 at Tunkhannock, Pa., a double track through girder bridge having 560 8 in. by 9 in. by 10 ft. ties, on both tracks. These ties were all renewed, the track replaced, the ties plated and full spiked and the iron guard rail placed in one day, between trains, and this without abandoning either track and passing 44 trains. This would have been impossible without the use of locomotive cranes.

METHOD OF SUBMARINE ROCK DRILLING AND BLASTING.

In connection with the construction of the ocean terminals at Halifax, N. S., much submarine rock excavation was necessary. This rock required drilling and blasting and removal with a dipper dredge. The following notes on this work are taken from a paper presented April 5 before the Canadian Society of Civil Engineers by Mr. A. C. Brown:

The more or less soft material overlying the rock in basins Nos. 1 and 2 was first removed by a dipper dredge, equipped with a 5 cu. yd. bucket. This dredge had a maximum dredging depth of 50 ft. and a minimum of about 15 ft.

After much consideration and comparison of systems of drilling in various classes of rock and of the results obtained, drill boat No. 1 and afterwards drill boat No. 2 were constructed.

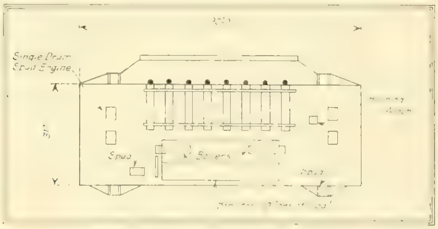


Fig. 1—Sketch of Drill Boat.

Drill boat No. 1 (see Fig. 1) consists of a wooden scow 35 ft. wide by 90 ft. long, fitted with 7 steam drilling machines with 5⅝ in. bits and 6 in. cable, 4 spud anchors with spud engines, two winch engines, locomotive boiler and electric light generating set.

The drills are spaced 7 ft. c. to c. and steam is supplied by two 40 H.P. boilers.

Drill boat No. 2 is similar to No. 1, only larger, consisting of a wooden scow fitted like No. 1, but containing 10 drills, 7 ft. apart.

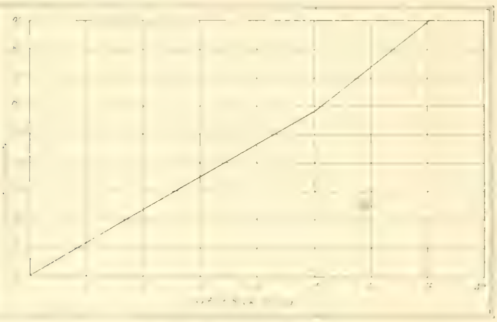


Fig. 2—Dynamite Chart.

The rock encountered consists for the most part of slate or shale with iron stone and an occasional trace of trap rock and quartz. It lies in very irregular inclined strata, being seamy and much broken, so much so that it is necessary to case all the holes with a 6 in. case pipe and to drive it sometimes for fully three-quarters the depth of the hole. This effectually cuts off the flow of sand, clay or mud contained in the seams of the rock, and so prevents the drills jamming. The holes are kept clean by means of a sand pump.

When the rock drilling and blasting first started the holes were drilled in rows 7 ft. apart, and about 2¼ lbs. 60 per cent dynamite were used to the cubic yard of material blasted. This was found to be excessive, and later the holes where the rock was deep were spaced 10 or 11 ft. apart, and about 1 lb. of 75 per cent dynamite was used to the cubic yard of material blasted. The dynamite chart, Fig. 2, shows the amount of dynamite to be used per foot of hole and is worked out on this basis.

Outside the wall foundations the drill holes are drilled to from 4 to 6 ft. below grade to ensure that the rock is broken fully to grade and that the dredged depth can be obtained with comparatively easy dredging. On the site of the wall foundations and within 10 ft. of them the holes are drilled to 3½ ft. below grade at 7-ft. centers, so as not to injure the foundations.

This system of drilling in the rock encountered has been very successful, and as much as 6,000 cu. yds. of rock have been drilled and blasted by the two drill boats in a week. Very little of the broken rock is larger than 1 cu. ft.

The method of shooting is as follows: After the holes are drilled the dynamite is placed in them, in cartridges made of stove pipe to fit the holes. The lead wires are brought up through the pipes and attached to floats. The pipes are then withdrawn. This is sometimes a troublesome operation, owing to the necessity of driving them well into the rock. In order to draw the pipes the drill boat by means of its spuds is tilted forward and the pipes made fast to the deck by collars and wedges. The drill boat is then tilted backwards lifting the pipes. This operation is repeated until the pipes are loose enough to be lifted by the drills. The drill boat is then moved to about 200 ft. from the blast, which is fired by means of an electric battery.

Most of the rock blasted has been dredged by a dipper dredge. It is equipped with 4 spuds for anchoring, the back two serving the double purpose of anchoring and propelling. It is also equipped with a 13 cu. yd. mud bucket and an 8 cu. manganese steel bucket for dredging in hard materials. It has a maximum dredging depth of about 55 ft. and a minimum of about 18 ft.

This dredge, working on material consisting of about 90 per cent rock, which was blasted by the drill boats, has been dredging between 9,000 and 12,000 cu. yds. per week.

Workmen's Compensation Laws.—At the beginning of 1917 there were 35 workmen's compensation laws in effect in the United States, including those of Hawaii, Alaska, and Porto Rico, but not including the new Federal act of 1916, which was not yet in operation, due to delay in the appointment and confirmation of the commission. Of the 17 noncompensation States, 10 are in a single group of Southern and South Central States—Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, Arkansas and Missouri. The other seven are the two Dakotas; the three mountain States of Idaho, Utah, and New Mexico; Delaware and the District of Columbia. In several of these, investigating commissions are now at work and in some it is probable that compensation acts will be adopted at the current sessions of their legislatures.

Sterilizing Tank for Pond or Stream Water.—A homemade water sterilizing device is used by the Illinois Central R. R. in cases where its employes on construction jobs must obtain drinking water from ponds or streams. The arrangement is as follows: Two barrels are set so that the bottom of one is about 3 ft above the top of the other. A 1-in. pipe is inserted in the upper barrel about 8 in. from the bottom and permits the water clarified by sedimentation to run through a stone filter and then into the sterilization tank. Hypochlorite of lime tablets are added to the water in the tank. The sterilization tank is provided with a drinking faucet. The sedimentation tank has a drain faucet at its bottom.

ENGINEERING METHODS FOR COAL STRIPPING OPERATIONS.

Engineering methods for coal stripping operations in the anthracite regions of Pennsylvania are practically standardized. An outline of these methods was given by J. B. Warringer in a paper presented last February at the New York meeting of the American Institute of Mining Engineers. The following notes are taken from Mr. Warringer's paper:

A base line is laid out parallel to the length of the stripping, with stakes at regular intervals of 20, 25 or 27 ft. These are numbered in order, beginning with one. At each of these stakes lines are laid out at right angles to the base line across the width of the stripping and stakes set at 20 or 25-ft. intervals. Sometimes these are numbered, but the best way is to assign letters to them, beginning with A. At any stage of the stripping operation these points can be readily relocated and levels run over them to ascertain the yardage removed. Cross-sections on each of the right-angle lines are plotted in the office on rolls of printed cross-section paper or tracing cloth. These plottings are invariably on a scale of 10 in. to 1 ft.

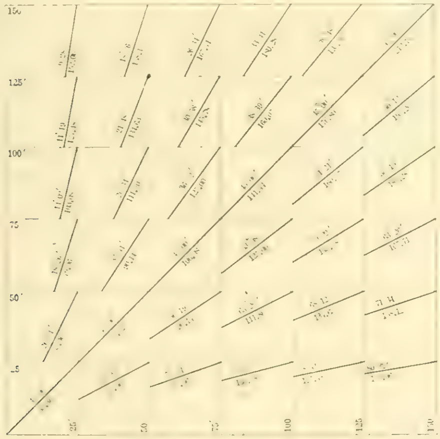


Fig. 1—Form for Calculating Monthly Yardage Excavations in Stripping.

The use of 27-ft. intervals along the base line is worthy of note, as it is rapidly coming into practice. By this method the area in square feet of the cross-section on each right-angle line can be translated into cubic yards without any multiplication.

At the lateral limits of a stripping it is customary to place limit stakes, using large stakes painted red or white to give them special distinction and permanence.

The overburden in stripping operations is classified usually as rock and earth. This classification is purely for convenience in carrying out the contractual relations when the contractor has undertaken to remove earth at one price and rock at another. Where the price of removing rock and earth is the same, no classification is required and the rate established is known as an unclassified rate. The definitions of rock and earth vary. As a rule, boulders of 1 cu. ft. and over in size are classified as rock, and all smaller as earth. Most variations in classifications occur at the gradation zone between earth and rock where the material to be excavated, though stratified and of the appearance of rock, is soft and of the consistency of earth. In some cases a third classification known as loose rock is employed, as is witnessed by the following definition:

> Loose rock will include all stone and detached rock found in separate masses, containing not less than 1 cu. ft. nor more than 1 cu. yd.; also all slate, coal or other rock, soft or loose enough to be removed without blasting, although blasting may be resorted to; also stratified rock in layers of 8 in. thick and under, separated by strata of clay.

As a rule, however, rock and earth are the only classifications needed. One particularly complete definition of these two classifications is as follows:

> Excavations shall be paid for under the following classifications: Earth, which shall include clay, sand, gravel loam, decomposed rock and slate, whether lying in place or not; stones or boulders containing less than 1 cu. yd., indurated clay or other earthy material, cemented gravel, and all coal, shale, slate, soft friable sandstone, and all other material in place except rock as hereafter defined; also stratified solid sandstone in layers of 8 in. or less in thickness when separated by stratified earth as above defined.
>
> Rock, which shall include all solid sandstone in place in layers greater than 8 in. in thickness, whether separated by layers of earth as above defined or not, and all boulders containing more than 1 cu. yd.

The loose-rock classification is undesirable and the tendency is, properly, away from it.

A special form which is of great labor-saving value to the engineers engaged in calculating the monthly yardage excavations is shown in Fig. I. The stripipng area is laid out in squares by parallel and right-angle lines. The illustration shows squares of 25 ft., but a similar chart could be worked up for any dimension. By means of this chart the intersection of any two lines can be found with the minimum effort and with field calculations eliminated.

METHODS FOR EXPEDITING HANDLING OF MOTOR TRUCK LOADS.

The accompanying illustrations show two methods developed by New England lumber dealers for cutting down the idle time of their motor trucks. The interchangeable body platform (Fig. 1) is used by the A. W. Burritt Co., Bridgeport, Conn., in connection with its four Federal trucks. The platform is carried by a horse-drawn wagon to the lumber piles. When loaded it is drawn to a shed in which there is a chain hoist. The chain is hooked onto the eyebolts at the four corners of the platform and the load raised from the wagon. The truck is then backed into the shed and the platform with its load lowered onto the truck.

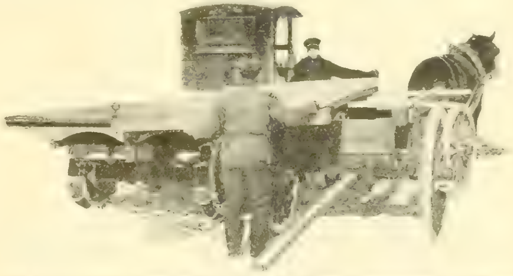


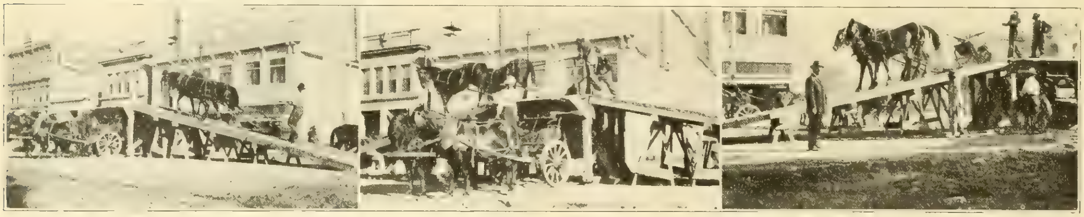
Fig. 1—Interchangeable Body Platform Being Transferred to Wagon for Loading While Truck Is Making Deliveries.

Cook, Borden & Co., Fall River, Mass., are using the trailer shown in Fig. 2 in connection with their $3\frac{1}{2}$-ton Federal trucks in delivering lumber. This trailer is loaded while the truck is delivering an order. The load is placed on rollers and fastened with chains. When the destination is reached the chain releases the load, the truck starts up and the lumber slides off onto the ground.

Fig. 2—Trailer Used by Cook, Borden & Co. for Lumber Deliveries.

TRAP EXCAVATION ON STREET PAVING JOB.

The method of trap excavation shown in the accompanying illustrations was employed with excellent success on a street paving job at Provo, Utah, by Ryberg Brothers, Contractors, Salt Lake City, Utah. The job was not of sufficient size to warrant the use of a steam shovel, nor was it large enough to require new equipment such as road graders, etc. The method illustrated accordingly was adopted and was found to be very satisfactory.



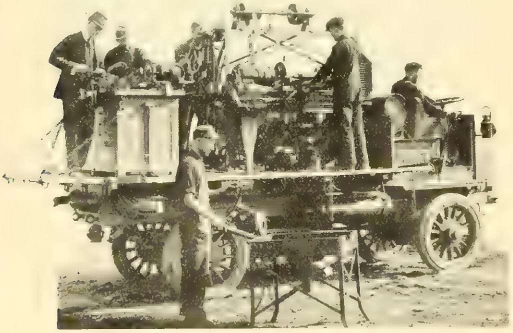
Trap Excavation Method Used by Ryberg Bros. on Street Paving Job at Provo, Utah.

A PORTABLE MACHINE SHOP.

An arrangement of particular interest to contractors has been placed on the market recently by the Four Wheel Drive Auto Co. of Clintonville, Wis. This is a compact machine shop mounted on a 3-ton truck chassis, thus making it possible to move from place to place on the job whenever repairs to construction equipment are required.

The machine tools consist of a 16-in. drill press and a 13-in. swing by 5-ft. screw cutting lathe. The electrical equipment includes a 5-HP. motor for the lathe, a 1-HP. motor for the drill press, an electric bench grinder operated by a 1-HP. motor and an electric breast drill. In all the outfit includes over 1,000 tools.

The power for operating the machine tools and for lighting the outfit is supplied by a direct current generator connected to an auxiliary 9-HP. 4-cylinder gasoline engine, which is entirely independent of the power plant furnishing the propulsive force for the chassis. In addition to furnishing electric light for its own requirements, the truck is capable of furnishing additional light for other purposes, and when not in use as a machine shop it can be operated as an electric light plant.



Compact Portable Repair Shop for Construction Work.

These machine shop trucks have been adopted by the U. S. Army to make field repairs on its fleets of trucks and road building machinery. If necessary, alterations can be made and other equipment installed on the truck to special requirements of construction operations.

American capitalists have submitted a proposition to the Russian government for construction of more than 800 miles of railway between Moscow and points on the Sea of Azov, at a cost of approximately $173,600,000. The railway, if constructed, will tap important coal fields in southern Russia.

NEWS LETTERS.

St. Louis Items.

T. W. Blythe can use three or four small team outfits. Farina, Mo., will catch him.

Wm. C. Nuttal, of M. C. Connors & Co., died in Chicago last week. From what we can learn he was ill only a few days.

The Heman Construction Co., Title Guaranty building, St. Louis, Mo., have eight miles of track laying in southern Illinois to sublet.

The Burlington Railroad Co. have several small pieces of team work to let in Illinois. Write E. A. Peck, Div. Eng., or A. Craine, Asst. Eng., Federal Reserve Bank building, St. Louis, Mo.

Mike Conroy has finished his big team job at St. Catharines, Ont., and is moving his outfit onto a two-years' job in Rochester, N. Y.

Ward Bros., 1062 Earl avenue, Cleveland, O., can use a 10 or 12-team outfit there. They also have some machine work to let at good prices.

J. C. Kaiser has moved his 20-team outfit from Charleston, Mo., to St. Louis. Working for the Hydraulic Pressed Brick Co. in the western part of the city.

Thomas L. Rosser, Jr., Earlham, Ia., can use a couple of 10 or 12-team outfits at that point. He also has a bridge and pile driving job in Illinois to sublet.

Contractors when in want of labor or work for their outfits write Koenig's Labor Agency, 612 Walnut street, St. Louis, or 503 Delaware street, Kansas City ,Mo.

James T. McMahon was awarded the contract for grading the site for the new Pullman Company shops in Northern St. Louis. About 175,000 yards of earth are to be moved.

Smith & Hannan can use a ten or twelve-team outfit on their Wabash Railroad work near DeWitt, Mo. Write Clarence Mitchell, superintendent of this company, Commerce building, Kansas City, Mo.

A. A. Luck, of the Luck Construction Co., Kansas City, Mo., was in town the other day looking for a job for his 25-team outfit and a couple of drag lines that they have idle. 524 Realton building, Kansas City, Mo., will reach him.

A. B. KOENIG.

PERSONALS.

Herbert Nunn of Multnomah County, Oregon, has been elected state highway engineer of Oregon at a salary of $3,600 per annum. Mr. Nunn came to Oregon from the state of Texas about three years ago.

Dr. D. B. Steinman, formerly special assistant to Gustav Lindenthal, consulting engineer, has joined the firm of Waddell & Son, consulting engineers, as associate engineer at the New York office, 165 Broadway.

Louis L. Brown, formerly vice-president The Foundation Co., and James H. Small, Jr., formerly chief engineer, Patrick Ryan Construction Corp., have incorporated the Louis L. Brown Co. and will engage in an engineering and contracting business, specializing in foundations by open and by pneumatic methods, shoring and underpinning, concrete, masonry and timber construction, rock and earth excavation and docks, bridges, tunnels. The offices are at 30 Church street, New York City.

George W. Cooley, state engineer and secretary of the State Highway Commission of Minnesota for eleven years, retired on April 11 from active service. When the Minnesota State Highway Commission was authorized by the legislature of 1905, Gov. John A. Johnson appointed Mr. Cooley to the position of state engineer and secretary to the commission and Mr. Cooley held the position ever since. Before going with the Highway Commission Mr. Cooley was county surveyor of Hennepin County.

Carlile P. Winslow has been appointed director of the Forest Products Laboratory at Madison, Wis., to succeed Howard F. Weiss, whose resignation takes place April 1. Mr. Winslow was graduated from the Sheffield Scientific School of Yale University in 1905, and entered the forest service in 1908. Since that time he has been engaged in research work in forest products. For the past four years he has acted as assistant to the director of the laboratory. Before entering the forest service Mr. Winslow was employed in general construction and engineering work. He is an expert on wood preservatives and has done considerable research work on this and allied lines.

Dr. Olin H. Landreth, professor of civil engineering at Union College, has been granted a leave of absence from college work for the year beginning in September, 1917. At his own request he will, at the end of the present year in June, be relieved of the administrative charge of work in the general engineering department, but will continue as a member of the engineering faculty as professor of engineering practice, the duties of which he will resume at the expiration of his leave of absence. The administrative charge of the general engineering department will be assumed after the present college year by Prof. A. B. McDaniel, who is at present assistant professor of civil engineering at Union College. Prof. McDaniel studied at the Massachusetts Institute of Technology, where he held an institute scholarship for 3½ years. He was graduated bachelor of science in 1901. He practiced engineering during the five years following and was assistant engineer on the East River division of the Pennsylvania tunnels, New York City, in 1905-6. Since then he has taught, having been successively instructor in civil engineering at the Case School of Applied Science (1906-7), professor of civil engineering at the University of South Dakota (1907-12), and assistant professor of civil engineering at the University of Illinois (1912-1916). From 1909 to 1911 he was also president of the Missouri Valley Engineering Company. He is author of Excavating Machinery (1913), of Earthwork (1915), of bulletins of the University of South Dakota and of the University of Illinois and of numerous articles published in the proceedings of engineering societies and in engineering journals.

INDUSTRIAL NOTES.

Contracts totaling approximately $2,000,000 have been placed recently with the Westinghouse Electric & Mfg. Co. of East Pittsburgh, Pa., by the New York Shipbuilding Co. for furnishing the necessary electrical equipments for the propulsion of the new superdreadnaughts Colorado and Washington.

Building and Structural Issue
of

Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

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OPPORTUNITIES FOR STRUCTURAL ENGINEERS IN SHIP BUILDING.

Every engineer who has been in the habit of reading English civil engineering periodicals has noted the preponderance of printed matter relating to ship building and the mechanical equipment of ships. The English have long been a nation of ship builders, as any one might readily infer from a study of the files of "Engineering" and "The Engineer" of London. Is America also about to devote a large part of its money and muscle to the building of ships? If so, many structural engineers may well begin to study the possibilities of securing employment as marine architects.

The announcement that Gen. George W. Goethals is to supervise the construction of a fleet of merchant vessels is welcome news to Americans in general and to engineers in particular. That a great executive engineer is to direct this enterprise of war is significant of a changed public attitude toward engineers. No longer is it being urged by the daily press that a business man, or a lawyer, or a "politician" should be placed in executive charge of work to be done by engineers and technical men.

Incidentally, be it noted, it was two engineers who simultaneously conceived the great plan which Gen. Goethals is to put through. F. Huntington Clark and F. A. Eustace, mining engineers, were the first to propose that America should build a fleet of wooden vessels to cope with the submarine menace. The Shipping Board saw in this plan the transcendent merit of rapid ship building at low cost. It is stated that a 3,000-ton wooden vessel can be built and equipped with internal combustion engines for about $300,000, or $100 per ton.

The Shipping Board believes that within six months these boats will be turned out at the rate of 200,000 tons a month, and that within nine months the output will be 500,000 tons a month.

Already a census of ship carpenters and others skilled in heavy timber work, calking, etc., is nearly completed, and the great enterprise of building an enormous emergency fleet is under way. W. P. Donnelly, a marine constructor of New York, is said to have evolved a novel design for a wooden ship which "will revolutionize the shipbuilding industry." Be that as it may, if Mr. Donnelly has not done so we may confidently look to other American engineers for the invention of something revolutionary in ship design, once the attention of many engineers is directed to the problem of economic production of ships on a large scale.

Now, important as this emergency shipbuilding will be, a vastly greater importance attaches to the subsequent results of this enterprise. We refer to the fact that American engineers and capital once enlisted in shipbuilding are not going to resign at the end of this war. There is no prospect that the infant American dye industry will be allowed to perish after the war. There is even less prospect that America will ever again permit herself to be driven from the seas by industrial competition.

For these reasons we urge structural engineers, particularly those of inventive skill, to lay hold upon the great opportunity now presented. The design of a ship largely involves problems of structural engineering. Those parts of the whole problem that relate to "skin friction" and "head resistance" are not difficult to master by any engineer. The problems of mechanical propulsion and equipment will naturally be given to mechanical and electrical engineers. The major part of the whole problem lies in the economic design and construction of ship hulls. It is this part of the problem that the American structural engineer is particularly competent to solve. Certainly the men who have made bridges by the league and buildings by acre are the very men who can turn out ships by the hundred.

HEAT CONDUCTIVITY OF DIFFERENT MATERIALS AS AFFECTING THE DESIGN OF BUILDINGS.

In the design of buildings for cold climates the heat losses through walls and windows deserve much greater consideration than they have, hitherto, received. How many architects or engineers know, for example, that an inch of pine or fir offers more resistance to the passage of heat than a foot of marble or than half a foot of ordinary concrete? How many who know such facts make any use of them in designing floors and walls? Undoubtedly many have studied the heat transfer problem but it needs only casual examination of the designs of buildings to make it evident that the majority of designers give very little thought to this subject.

In our next Building and Structural Monthly issue, we shall give the latest theory of heat transfer, including the resistance of air films, and we shall also give a very complete table of coefficients of heat conductivity. The following are some of these coefficients, expressed in British thermal units per square foot per hour per degree of temperature (F.) difference between the two faces.

Brickwork	4.8
Concrete, stone aggregate	6.4
Concrete, cinder aggregate	2.3
Glass	6.6
Limestone	13.7
Marble	14 to 28
Plaster (lime and sand)	3.9
Fir (across grain)	1.4
Oak	1.7
Pine	1.1
Strawboard	1.0
Water	4.0
Air	0.17

As will be shown in our May 23rd issue, a quiescent air film, one-sixth of an inch thick, adheres to all solids at low temperatures and when no wind is blowing. It is these air films that prevent the enormous heat loss that would otherwise occur through the thin panes of a window. And, as we have pointed out in previous issues, the use of double windows or of double glazing is effective because of the doubling of the number of air films.

Concrete or stone floors on which men must stand in cold weather are uncomfortable, but the table above given shows that cinder concrete is greatly superior to stone concrete as a heat insulator. It approaches oak in this respect. Cinder concrete, because of its light weight, is frequently used for floors; but who has hitherto suggested its use because of its low coefficient of heat conductivity?

Two inches of cinder concrete offers almost as much resistance to heat loss as six inches of stone concrete. Is this fact not well worthy of consideration in the finishing of concrete walls? Why should not cinder concrete be used as a plaster for the inside of walls of buildings? Indeed, might it not pay to plaster walls with sawdust concrete?

Strawboard and building papers, it will be seen, offer a very high resistance to heat transfer. But why attempt to secure this resistance by increasing the thickness of the paper? Why not use thin paper corrugated and laid in several layers, the corrugations holding the paper layers apart? Thus a number of air films would be secured.

The high heat resistance of all fibrous or granular substances is due almost entirely to the air films around the fibers or grains. But the same effect is often secured more cheaply by the use of a series of thin sheets of material, such as paper, separated by about one-third of an inch, so as to give the two adjoining air films their full thickness. The prevalent idea is that there must be a wide air space between layers—as in hollow walls—to secure great resistance to heat transfer. This is an erroneous idea, and it behooves every designer of buildings to know why it is erroneous. Accordingly the modern film theory of heat transfer will be discussed at length in our May 23rd issue.

IF FIRE PROTECTION WERE FURNISHED BY INSURANCE COMPANIES.

Fire protection is so commonly regarded as being inevitably a municipal function that few business men have ever asked themselves this question: What would be the economic effect of turning over all fire fighting apparatus and the management of city fire departments to fire insurance companies? What would be the further effect of authorizing the fire insurance companies to collect the cost of fire protection as a part of the premiums charged on fire insurance policies?

If this were done it is evident that it would not long remain profitable to erect "fire traps" in cities. At present the fireproof building is actually taxed to protect the "fire trap." This anomalous condition arises from the fact that city fire departments are supported by general taxation of all city property. A fireproof building being more costly than one that is not fireproof, therefore pays a larger part of the fire department expense. Thus we have the economic absurdity of a fire department supported most by taxes on property that least needs its services.

Were conditions reversed, as they should be and as they would be were fire protection furnished by fire insurance companies, the increased expense of protecting inflammable buildings would lead to their rapid elimination.

Were fire departments operated by insurance companies, thus converted into public service companies, there is not the slightest doubt that fire protection would be greatly improved without increasing the cost. Undoubtedly the cost would be considerably decreased.

Insurance companies are quite likely soon to be classed as public utility companies, anyway, with their rates subject to commission regulation. If not this, then state insurance is likely to displace company insurance.

Only 50 per cent of the premiums of fire insurance companies go to pay fire losses. Operating expenses and taxes take about 25 per cent, and commissions absorb 15 per cent of the premiums, the remaining 10 per cent being profit. Were competition eliminated the operating expenses and commissions could be greatly reduced. By combining the management of fire protection and fire insurance, a further saving could be effected.

WHO INVENTED THE MODERN SKYSCRAPER?

Thomas Nolan, professor of architectural construction of the University of Pennsylvania, recently delivered a public lecture in which he said:

> There has been some controversy in regard to priority of invention of first use of metal skeleton construction. It is generally agreed that it was first developed in Chicago in 1889 and recognized as a definite and new contribution to the science of construction in American architecture.

Professor Nolan said that the steel skeleton frame has been classified as the last of the four great developments of structural advances, which have given architecture really new resources, the first being the Roman vaults, the second the Gothic ribbed vault and flying arch and buttress and the third the metallic truss. Steel beams were first manufactured in 1895 by the Carnegie Steel Co. at Pittsburgh, Pa.

Who invented the steel skeleton frame and made possible the modern skyscraper? Among our Chicago readers there should be those who can give a definite and conclusive answer to this important question. We fail to find the name of this inventor mentioned in any book on structural engineering or architecture.

Prof. Nolan said:

> The inception and growth of the high building has been made possible by the introduction and rapid development of structural steel, light fireproof materials, passenger and freight elevators, and by great advances in the mechanical equipment, isolated foundation supports and wind bracing.
>
> Previous to 1885 "tall" buildings were not more than eight or ten stories high—this height was very nearly the practical limit—and their construction was then sometimes referred to as "elevator architecture." The next stage in the evolution of the tall building was the one in which the entire weight of the floors and roofs and the loads on them were carried by a system of metal columns, the exterior walls thus supporting no load but their own weight. Buildings were carried by this form of construction to the height of eighteen or nineteen stories.
>
> With the introduction of cheap structural steel the steel "skeleton" or "cage" construction came rapidly into use. Formerly the "skeleton" type was carefully distinguished from the "cage" type of tall building construction, the former term being applied to buildings which might have the outside walls self-supporting and which depended somewhat for stiffness upon walls, partitions, floor filling, etc.; and the term "cage" being applied to buildings which consisted of a complete and well-connected framework of metal designed to carry not only the floors, but the walls, roof and all other parts of the structure, and furnished with wind-bracing members.

USE OF SAFETY NETS IN BUILDING CONSTRUCTION.

For more than a year safety nets made of rope have been used in the erection of high buildings in Chicago, and, during that period, at least two lives have been saved by their use.

The nets are made of ½-in. manila rope with a ¾-in. border and a 4-in. mesh. A net 10x30 ft. costs $60 to $70, and has a long life. The small annual cost of such protection is abundant reason, entirely apart from humanitarianism, for the extensive use of this invention of P. T. Barnum, or some less renowned circus proprietor.

THE TORRENS SYSTEM OF LAND TRANSFER.

"This is the maiden all forlorn that milked the cow with the crumpled horn that tossed the dog that chased the cat that worried the rat that ate the malt that lay in the house that Jack built."

With slight variation, this nursery rhyme forms the model upon which the legal transfer of real estate is based. When you get an abstract that goes with the deed to a piece of land, you get an endless chain jingle:

This is the land that Jonathan Jones sold to Faithful Truthful Grones, who sold to the widow of Simpson Smith and she to Gregory Grumty Grith, * * * who sold to another and he to me, and all this folly to pay a fee.

Sixty-five years ago Sir Richard Torrens, of Australia, rebelling at the endless chain nonsense of the land transfer system, perfected what is now known as the Torrens system which was put into effect in Australia. The main points of the system are:

1. An official registrar of titles.
2. An official examination of titles.
3. Establishment of titles once for all.
4. The transfer of title by the issue of the official certificate and registration of the transfer.

The state, therefore, stands back of the transfer of every certificate of land ownership, much as a stock company stands back of a transfer of stock. Real estate certificates under the Torrens system have the mobility of stocks or bonds. Endless fees to lawyers and title insurance companies are eliminated.

A few of our states have made the Torrens system permissive, but none has made it compulsory. The abstract companies and others that continue to fatten on the old fee system have thus far been powerful enough to block sweeping legislation that would wipe them out and greatly simplify the buying and selling of land.

Is this not one of the matters of public concern in which engineers might well take steps to lead a reform?

EDITORIAL COMMENT.

A cement wash can be applied effectively and economically to ribbed concrete surfaces by the aid of a paint-spraying machine of the type ordinarily used with cold-water paint. A small hand pump operates the sprayer. One man mixes, another pumps, and a third handles the nozzle, thus covering a much larger surface per man than by hand brushing. The finish is more uniform and better than is secured by brushing.

The longest single truss span in the world, 720 ft., is that of the Metropolis (Ill.) bridge across the Ohio, recently completed by the American Bridge Co. for the C., B. & Q. R. R.

By a mail canvass of 10,000 architects and engineers, "Structural Conservation" secured more than 2,600 replies to queries relative to integral waterproofing. More than 94 per cent favored integral waterproofing of concrete under hydrostatic pressure, and 92 per cent stated that their observation had shown that integral waterproofing is beneficial in filling the pores of concrete and preventing the absorption of moisture, whereas concrete not waterproofed is absorptive of moisture.

A temporary footbridge, supported on pontoons made of barrels, was built across Trinity River, Dallas, Texas. The 4-ft. walk was supported on light timber bents, 6 ft. apart, and each bent was upheld by four barrels. The barrels floated inside a wooden grillage that held them together. Thus a 50-ft. bridge was built for $1.50 per ft.

The bureau of bridges of the Illinois Highway Department in 1913 prepared plans and specifications for 238 township and county bridges; in 1914, 243; in 1915, 381, and in 1916, 630. The bureau drafted plans and specifications for state aid bridges as follows: in 1914, 26; in 1915, 326, and in 1916, for state aid construction and in connection, 3,860. The grand total of all plans in 1916 was 4,600, the estimated cost of the structures amounting to $1,558,000.

In the description of the new $2,500,000 Curtis Bay coal pier of the Baltimore & Ohio R. R., in our March 28th issue, it should have been stated that the methods used for the handling of coal at the pier were the invention of Francis Lee Stuart, who was chief engineer of the railway when the work was designed and the construction begun.

The revised standards of the State Highway Department of Michigan for pony truss bridges provide inside knee bracing at every panel point which, being connected directly to the floor beams between the trusses, gives greater stability to the trusses. The hand railing is connected to the battered braces. There is greater weight in the floor beams but to offset this there is less weight in the inside knee bracing than in outside bracing on account of no horizontal member being required as in the outside brace. The added length of floor is not lost but provides a greater width of roadway. Although the nominal width of roadway may be but 18 ft., measured from out to out of curb, there is actually about 19 ft. clear width 3 ft. above the crown and 20 ft. at 6 ft. above.

DOUBLE GLAZING OF SASHES.

To the Editor: I am interested in your editorial comment on page 49, March 28 issue, of Engineering and Contracting in re double glazing of sashes.

I have not the slightest doubt as to the general accuracy of the conclusions indicating the heat saving effected by the double glazing. I do, however, take exception to the calm and inconsequential way in which you dismiss the objections to double glazing. As much as 20 years ago I was thoroughly convinced of the value of double glazing from the purely practical point of view, and I am sure that if the objections could be thrown aside as easily as you seem to think double glazing would be universal in northern latitudes.

Unfortunately, I have not had the privilege of reading the original article to which you refer, and do not know whether the author limited his advice in any way or not. I can conceive it to be quite possible that if extreme care were taken in the original glazing to have and to keep the glass thoroughly clean and polished at the time of setting, such double glazing might prove very satisfactory for factories and buildings where the immaculate condition of the window glass is not material. Double glazing of windows in places where a good housekeeper has supervision over the cleaning is, however, something that no architect who values his reputation with his client would ever dare put over.

To begin with, it is an exceedingly nice job to glaze windows in this way and do it with the cleanliness and neatness requisite for high-grade residential work, all of which would add very materially to the expense and would go a long way toward offsetting the actual saving in coal. This might be immaterial with many persons, but the real objection is that in spite of all care that can be exercised a thin film of dust will, probably not in one year or two years but in the course of several years, gather on the inside of the glass sufficiently to dull its brilliancy and discredit the man who is responsible for its installation.

Double glazing, like Christian Science, has good points, but for these good points to be brought out most effectively its limitations must be recognized.

Clarence A. Martin,
Dean, College of Architecture,
Cornell University.

Ithaca, N. Y.

NATIONAL SOCIETY OF STRUCTURAL ENGINEERS.

To the Editor: The article in your issue of March 28, entitled "The Proposed National Society of Structural Engineers" has been read with interest by the writer. You invite letters from your readers in connection with this matter. Consequently, I am writing to suggest that the proposed Society should include bridge engineers as well as structural engineers who are engaged on the design of buildings. The interests of both these classes of engineers would appear to be coincident, and there are many engineers who engage in work of both classes. Why the implied exclusion of bridge engineers?

F. H. Frankland,
Associate Engineer,
Waddell & Son, Consulting Engineers.

New York City.

Tests of Strength of Hollow Tiles.—At the request of several manufacturers of hollow tile, a series of investigations of the strength of this material as developed in walls of varying thicknesses has been started in the U. S. Bureau of Standards by the construction of a number of these walls 5 ft. long by 12 ft. high. The walls so far constructed are of three thicknesses—6, 8, and 12 in. Those already laid up have been set with the tile placed on their sides. Other variables will enter into the work, and when the investigation is completed about 50 will have been built.

EXTRACTS FROM LETTERS SHOWING WHAT THE SUBSCRIBERS THINK OF THE ROTATED SPECIAL MONTHLY ISSUE FEATURE OF ENGINEERING AND CONTRACTING.

The system you have adopted in specializing each issue of Engineering and Contracting has met a long-felt want in a number of ways, especially in classification for filing. Why didn't you think of it sooner? It would have made the old issues of more value. As it was, I had to classify some magazines under three or four headings.

F. O. Kirby,
Consulting Engineer.

San Antonio, Tex.

I wish to compliment you on the new method of editing and publishing Engineering and Contracting. It is the best plan that I have ever run across in my experience as an engineer. It appeals to me, if for no other reason, because of the fact that I am able to place my hand on a particular subject without having to dig through the entire issue hunting for this special topic. Some of us who are very busy do not have the time to digest all of the issues. Consequently, when that special number is published in which we are interested it saves us a great deal of time which we otherwise would have to use in hunting up this particular subject.

R. V. Orbison,
City Engineer.

Pasadena, Cal.

In my opinion, the new arrangement, in accordance with which Engineering and Contracting devotes one issue in each month to special fields of engineering activity, has very decided and obvious advantages. Such an arrangement must result in the concentration of the attention of the staff of the magazine on the special field treated in each issue and such concentration should produce a better product. There is, of course, much greater ease and a saving of time in referring to back numbers of the magazine, and the binding together of the numbers referring to one subject will make this convenience still greater. The separation of the subscription so as to permit each subscriber to select his special subject, if he is not interested in all, is also an advantage. For myself, I am particularly glad that a special number is devoted to planning and management. The subscription of this department will be continued for all numbers.

Manuel V. Domench,
Commissioner of the Interior.

San Juan, Porto Rico.

I compliment you upon the improvement made in your always valued Engineering and Contracting, through the adoption of your rotated monthly special issue.

Louis Simpson.

Ottawa, Ont.

I much prefer your new method of editing the magazine to the old. I believe that each of the four phases of engineering will receive its share of attention now, while under the old plan some one phase might have been neglected for perhaps a timely article on some other phase. Also under your plan it is much easier to index any other subject. I index and file the copies relating to subjects in which I am interested and only make clippings from the others.

T. E. Bliss.

Memphis, Tenn.

I consider your paper, the new Engineering and Contracting, in its new dress and manner of appearance to be handy, very usable and quite convenient. It is a big innovation in the publications on engineering.

H. L. Newman,
Chief Draftsman P. S. & N. R. R.

Angelica, N. Y.

GRAPHICAL DETERMINATION OF THE STRESSES IN ECCENTRICALLY LOADED REINFORCED CONCRETE COLUMNS.

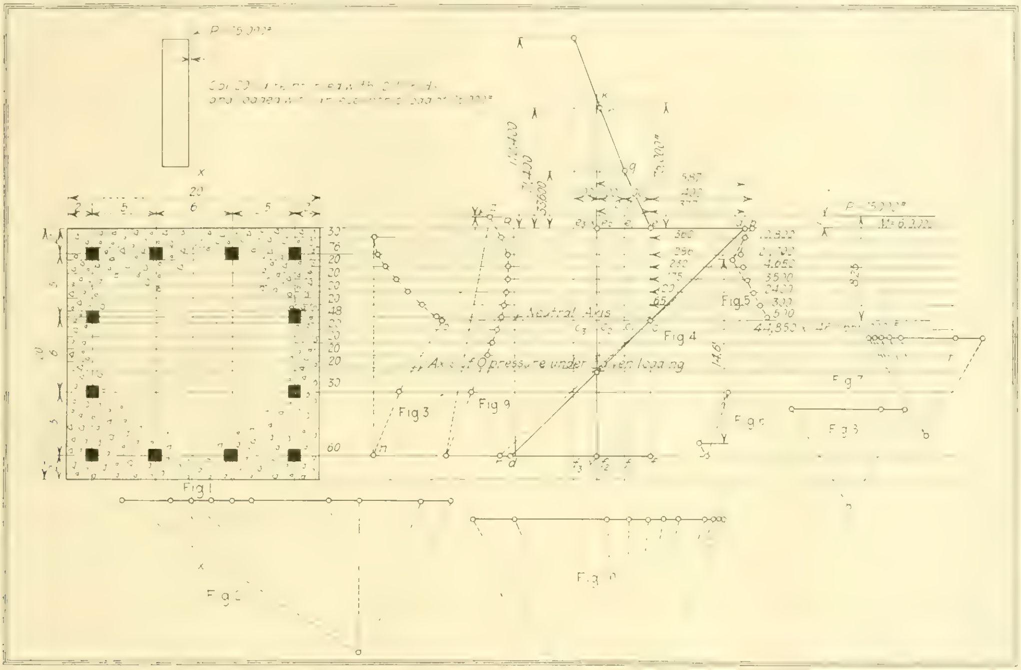
Contributed by W. S. Wolfe, Instructor in Architecture Engineering, University of Illinois.

Figure 1 shows the cross section of a reinforced concrete column, reinforced with twelve 1-in. square bars, and of dimensions as shown. This column is loaded with an eccentric load of 75,000 lb., acting 1 in. outside the edge of the column. It is desired to find the maximum unit stress in the concrete and steel, assuming that the load is symmetrically placed about the axis XX, Fig. 1. In this solution the effect of the bending moment produced by the eccentricity of the load, will first be considered, after which the effect of the direct load will be added.

The neutral axis is located by means of Figs. 2 and 3, and the base line e f is drawn in Fig. 4. The length e b is measured off to represent some convenient number of pounds per square inch, in this case, 400, and the line b c r is drawn. From the intercepts between the lines c f and c r the stress in the tension steel may be found. Figs. 5 and 7 locate the resultant of the compressive stresses. Figs. 6 and 8 locate the resultant of the tensile stresses, and the effective depth is found to be 14.6 in., from which 656,000 inch pounds is found to be the resisting moment when the maximum stress in the concrete is 400 lb. per square inch. The eccentricity of P measured from the neutral axis is approximately 8.25 in., therefore the load produces a moment of 619,000 inch pounds. Now, if the resisting moment is 656,000 inch pounds when the maximum concrete stress is 400 lb. per square inch, by proportion the maximum stress in the concrete produced by a bending moment of 619,000 inch pounds will be 377 lb. per square inch, shown to scale as e a in Fig. 4.

The effect of the direct load will now be considered. A direct load applied at the neutral axis will have the effect of moving the base line e f to the left, thus increasing the compressive stresses and decreasing the tensile stresses. Assume the base line e f to be moved to e_1 f_1, a distance of 100 lb. per square inch. The increase of compressive stresses is added to the decrease in the tensile stresses and found to be 33,600 lb., which is laid off to scale along the line e_1g, thus locating the point g. In other words, a load of 33,600 lb. applied approximately at the neutral axis would move the base line e f to e_1 to e_1f_1, increasing the compressive stresses in the concrete 100 lb. per square inch and decreasing the tensile stress in the tension steel 100.n = 1,500 lb. per square inch. The base line is now moved another 100 lb. per square inch to the left, and the additional increase in compressive stresses plus the decrease in the tensile stresses is added to the 33,600 lb. already obtained, making 71,400 lb. which is laid off along e_2 h, thus locating h. Again the base line is moved 100 lb. per square inch to the left, reaching the position e_3f_3 and i is found to be out a distance of 112,400 lb. Now draw the curve e g h i and locate k, the point where the 75,000-lb. line cuts; then draw the base line k x y and a x = 587 lb. per square inch = the maximum stress in the concrete and y d times n = the miximum tensile stress in tensile steel. That is, a load of 75,000 lb. applied approximately along the neutral axis will move the base line e f to the position x y, thus increasing the compressive stress in the concrete 210 lb. per square inch and decreasing the tensile stress in the steel y f times n = 210 times 15 = 3,150 lb. per square inch. Now a slight approximation has been made in assuming that a load applied at the neutral axis moves the base line directly to the left. This assumption is exactly correct to start with, but as the base line moves to the left, more area comes under compression and the position of the load must move slightly toward the tension side of the beam in order to keep the base lines parallel. This deviation from the neutral axis, however, is only slight as long as there is very much tension in the column. For example, when the base line has moved to e_1f_1 the load should act through c_1 in place of through c, when the base line has moved to e_2f_2 the load should act through c_2, etc.

As a graphical check on the work the compressive and tensile stresses in the column when the base line is x y are found and laid out in the force polygon, Fig. 10, from which the funicular polygon, Fig. 9, is drawn locating their resultant, which, of course, should have the same action line as the applied load P. The error is found to be z, which is just about as large as the error made in assuming that the eccentricity was the distance from the neutral axis to the action line of P. If it is desired to make a correction for this error, add z to the eccentricity used. This will increase M slightly, which will increase the length of e a, in this case from 377 to 383 and the maximum stress in the concrete is 583 lb. per square inch.



Figs. 1-10—Diagram for Graphical Solution of Reinforced Concrete Column with Eccentric Load.

Analytical Check.—It is rather difficult to get a very accurate analytical check on this work because I have considered a column with reinforcing rods on all four sides, while the formulas usually derived for eccentrically loaded reinforced concrete columns consider reinforcement only on two sides. If reinforcement was considered on all four sides the formulas would no doubt become very complicated. Also in developing formulas it is customary not to deduct the concrete displaced by the compression steel, thus introducing a small error. Now if the four rods nearest the line of zero pressure are neglected, we would expect the maximum stress in the concrete to be slightly increased. Neglecting these rods and using the diagram on page 288 of the second edition of Turneaure & Maurer's "Principles of Reinforced Concrete Construction," the maximum pressure on the concrete is found to be about 600 lb. per square inch, which is, as would be expected, slightly greater than the result obtained by graphical solution in which all of the rods were considered.

Advantages.—This method makes unnecessary the development or use of formulas, and also makes it much easier to understand how the internal stresses are distributed and how their distribution is affected by the bending moment and by the direct load. Another advantage of this method is that the complicated cases and those in which the reinforcement is placed on all four sides, can be handled with ease.

This same general construction can be used in determining the stresses in a reinforced concrete chimney when the wind is strong enough to produce tension over a part of the section. It would be very difficult to handle such a problem by analytical methods unless a good many approximations were made. This general construction may also be used to determine the correct stresses in the anchor bolts and under the bases of steel columns which are anchored to the foundation in such a way as to resist bending.

$75,000,000 for Buildings for New U. S. Army.—Plans are well advanced for the construction of the cantonments to shelter the emergency army of the United States of 43,000 officers and 1,034,000 enlisted men. The estimated cost of providing temporary construction, etc., is $75,650,000. The item for erection of temporary buildings amounts to $40,290,800. Temporary hospitals are to be built to cost $2,014,540; water and sewer systems will cost $2,490,000; electric lighting systems, $604,000; roads, $5,036,000. The location and size of these camps have not been determined, and it is still a question whether the War Department will purchase the material and engage general construction companies to erect the buildings or award contracts for the complete work. It is planned to erect at Fort Myer, Va., a series of sample buildings arranged in units of various types of construction, and the departmental designation of a type will be governed, not only by price and availability of material, but by considerations of climate. One of the types will be of metal, another of concrete (which includes the roof), and a third of frame (of the "knock-down" variety). The buildings will be of one story and of the simplest design. The "layouts" will be for brigade headquarters, a regiment, a battalion, and a company. The officers' quarters for a regiment, for example, will be 84 ft. in length and contain at one end the kitchen and mess room with offices at the other; between will be separate sleeping rooms for six officers.

RESULTS OF EXTENSOMETER MEASUREMENTS IN A REINFORCED CONCRETE BUILDING OVER A PERIOD OF 1 YEAR.

The results of a long-time extensometer test of a reinforced concrete building were reported by Arthur R. Lord, Consulting Structural and Testing Engineer, Chicago, Ill., in a paper presented at the last annual meeting of the American Concrete Institute. In his paper, which is reprinted below practically in full, Mr. Lord describes tests made of the Schwinn Building, Chicago. This building was designed by Lieberman & Klein, Consulting Engineers, shortly before the present Chicago Flat-Slab Ruling went into effect. At that time each designer was required to satisfy the building department as to the sufficiency of his design either by previous tests of similar constructions or by submitting the proposed building to an extensometer test prior to its occupation. Mr. Lord was employed by the city as Testing Engineer on this occasion, and it was at his suggestion, with the hearty consent of the designing engineers, that the test load of twice the designed dead and live load was required to remain in place one full year. The ordinary extensometer test was first made in the usual manner, readings of deformation being taken under various degrees of loading, and a final reading being taken when the full test load was in place 24 hours. From that point 44 gage lines of representative character and showing the greatest stresses of their kind and location were selected, and these lines were measured during the further period of slightly over one year. The results are reported herewith:

The Schwinn Building, occupied by the Excelsior Motor Manufacturing and Supply Company, is located at Lawndale avenue and Cortland street, Chicago. It is six stories and attic in height, approximately 673 ft. long by from 80 to 138 ft. wide. The building is divided at the center by a fire wall and an expansion and contraction joint was made at this point, the slab being designed to slide on the same beam that supports the wall. The panel tested was selected by Mr. Jensen of the Chicago Building Department. In view of the size of the panel (approximately 25 ft. by 26 ft.) and the amount of test load involved, only one panel was loaded. It was located on the 6th floor, where the columns were the smallest and the effective span the greatest. There were two flat slabs above the slab tested and four below. The elevators, toilets and washrooms for the building were located in service wings and one of these projected from the panel immediately adjoining the test panel. The attic was used as an air storage and circulation chamber and was connected with the various stories by means of concrete and metal ducts. The concrete ducts were built on the outside of certain wall columns, and the metal ducts carried through holes in the floor slab adjoining each wall column. One concrete duct adjoined the test panel and openings for two metal ducts were present at each of the wall columns of the test panel.

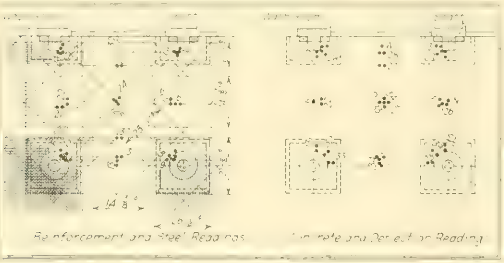

14' 8"
Reinforcement and Steel Readings
Concrete and Deflection Readings

Fig. 1—Details of Slab Reinforcement and Location of Gauge Lines and Deflection Readings.

Details of Test Panel.—The details of the slab reinforcement are given in Fig. 1. One-third of the slab rods in each direct band were carried through at the column and lapped, without being bent up to take tension. All the diagonal bars were bent up. The slab was designed to be 9½ in. thick, but actually measured a uniform 10 in. in thickness practically throughout the area of the building. The slab steel at the column was not raised to take advantage of this increased thickness, however. The interior drops were 9 ft. square at their lower surface and 6 in. thick. The edges were beveled to a 10 ft. 6 in. square at the under surface of the slab. The wall drops were of corresponding size, but only 4 in. thick. The exterior walls were of concrete, standing 3 ft. above the floor level, and 9 in. thick. The wall columns were 6 ft. 6 in. wide by 1 ft. 6 in. thick, with a pilaster 2 ft. 6 in. wide by 1 ft. thick at the center. They were reinforced with 16¾ in. rods 14 ft. 6 in. long and tied at intervals of 9 in. with ¼ in. wire.

The interior columns were built as follows:

C-18, 5th story, 28 in. dia., 24-in. spiral ½ in. at 2¼ in., 11 1-in. sq. rods.

C-18, 6th story, 26 in. dia., 22-in. spiral ⅜ in. to 2 in., 8 ⅞-in. sq. rods.

C-19, 5th story, 26-in. dia., 22-in. spiral ⅜ in. at 2 in., 8 ⅞-in. sq. rods.

C-19, 6th story, 26-in. dia., 22-in. spiral ⅜-in. at 4-in., 8 ¾-in. sq. rods.

The concrete in the test panel, columns and wall was of 1-2-4 mixture. The columns were poured on June 12, 1914, and the test panel on the following day. The wall was poured to the sill level about 3 hours after the slab was placed and the wall columns were poured to the same height at the same time. The cement floor finish (from 1 in. to 2 in. thick) was laid on the following day, the total thickness of slab and finish being 10 in. The top steel was placed after the rough floor slab concrete had stiffened considerably, and was from 1¼ to 1¾ in. below the top of the slab. The structure was "fireproof," with not less than 1 in. of concrete over and under all slab steel.

Auxiliary Test Specimens.—Concrete specimens in the form of 6-in. cubes, 8-in. x 8-in. x 16-in. prisms and 6-in. x 8-in. x 54-in. control beams were taken at random from the concrete actually placed in the test panel. Cubes and prisms were shipped to the University of Illinois for testing, one-fourth at the time of the 24-hour test and one-fourth at 4 months, 8 months and 1 year thereafter. The control beams were tested at the building at the time of the 24-hour test. All specimens were stored on the floor up to a few days before the test began.

Control beams loaded at the third points on a 4-ft. span gave a modulus of rupture for two specimens of 181 and 190 lb. per sq. in.

Test Loading.—The first load was placed on the test floor on Aug. 14, 1914, amounting to an average depth of 22 in. of bank sand (about 160 lb. per square foot). On Aug. 15, the load was increased to an average depth of 38 in., very well compacted. The car weights gave the total load as 192,000 lb. (about 300 lb. per square foot). On Aug. 17 the load was finally increased to an average depth of about 57 in., the total car weight being 289,600 lb. (about 460 lb. per square foot). Allowing for a small loss in handling the sand from the cars to the test floor the test load may be considered to have been 450 lb. per square foot, and this load remained in place until Sept. 2, 1915, a period of somewhat over one year. The load was necessarily reduced at various points where shelters were built to enable observers to work, but the sand was piled higher and thoroughly compacted at these points and the resulting load condition is believed to have been not far from uniform. This

TABLE I—TESTS OF CONCRETE SPECIMENS.

	Compressive strength		Modulus of elasticity.
	Cubes.	Prisms.	Prisms.
Age	Lb. per sq. in.	Lb. per sq. in.	Lb. per sq. in.
Sixty seven days	2,420	2,150	3,700,000
About 4 months	3,180	2,570	3,500,000
About 10 months	3,080	2,733	4,350,000
About 13 months	*2,100	[illegible]	3,400,000

*One specimen chipped at edge.

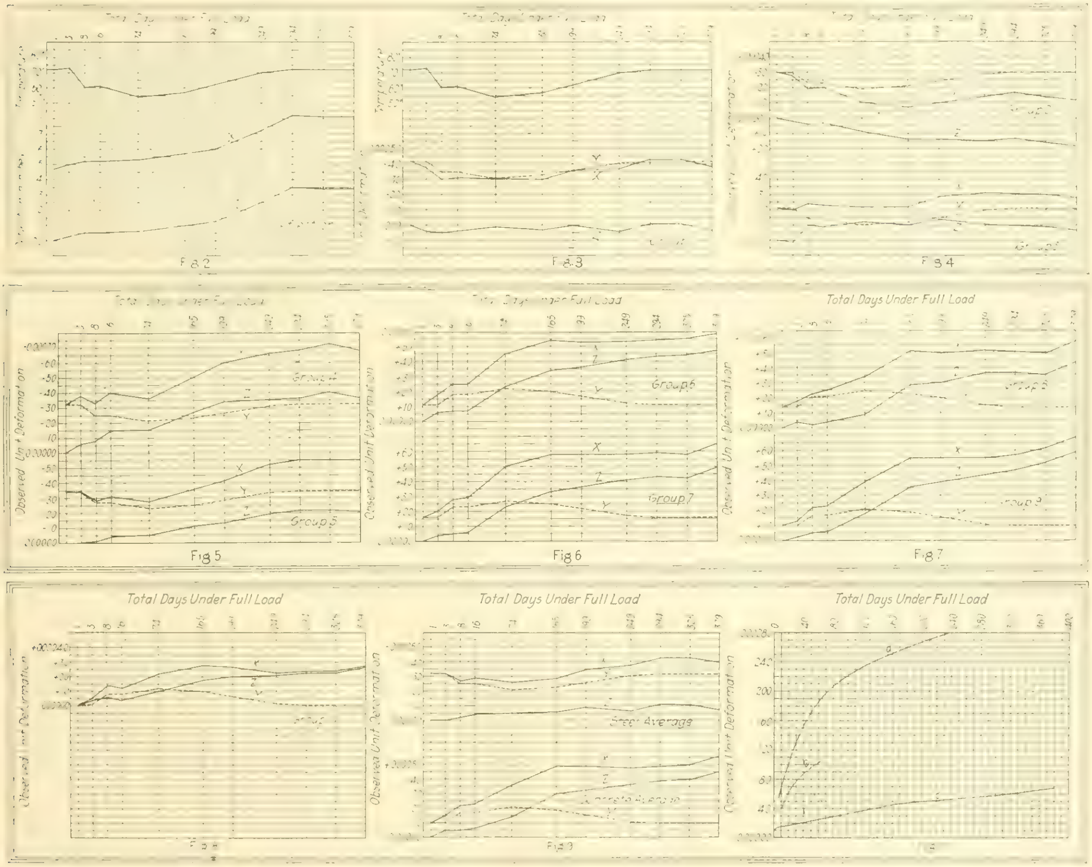
floor was designed for a uniformly distributed live load of 150 lb. per square foot.

Test Readings.—To and including the completion of the 24-hour test (full test load in place for 24 hours), 90 gage lines on the steel and concrete were read continuously with a University of Illinois type of Berry extensometer. Temperature variations in the instrument were corrected by reading on an invar steel standard bar. For the continuation test of one year only 44 gage lines were read, the lines showing the highest stresses at the 24-hour period being selected for this purpose, including, of course, representative gage lines of both steel and concrete in all parts of the floor. The gage lines are located in Fig. 1. Deflections readings (location also shown in Fig. 1) were established at the panel center and near the center of each edge. The readings reduced to unit deformations are plotted in Figs. 2 to 9.

Deflections Readings.—The deflection at the panel center is plotted in Fig. 2. The matter of devising an apparatus for measuring deflections that should be proof against damage from men working in the building was not satisfactorily solved until some time after the test began. There are gaps in all the deflection readings for the edges of the panel and it was only by virtue of taking two independent series of observations by different methods that a gap in the panel center deflection record was avoided. Both series were broken, but not in any one interval.

The test required that several panels on both the 6th and 5th floors should not be occupied for manufacturing and storage purposes, and while no friction developed several events transpired to interrupt the smooth working of the program planned. The extensometer measurements were not affected by such interruptions, but merely the regularity in taking the readings. No part of the 6th floor for several panels around the test load was used during the year (except for light trucking) and it is believed that the effect of loading adjacent panels is not involved in this test.

A study of Fig. 2, comparing the temperature and deflection curves for the year, would indicate: (1) a general tendency for the deflection to increase at all times during the year and especially during the earlier stages of adjustment, due, presumably, to the plastic yielding of the concrete; and (2) a general tendency for the deflection to decrease as the temperature falls and to increase as the temperature rises. In the first 74 days when the temperature was falling the natural increase in deflection with time was very largely prevented by the tension brought upon the floor due to the falling temperature. From 74 days to 294 days the rising temperature and standing load were both acting to increase deflections. In the final three months of practically constant temperature the deflection remained nearly constant.



Figs. 2-10—The Readings Reduced to Unit Deformation Are Shown in the First Eight Cuts. Fig. 10 Compares the Fuller & More Data with Schwinn Building Tests.

Grouping of Test Observations.—Figs. 3 to 9 show the average observed unit deformations in the steel and concrete arranged in groups of similar observations as follows:

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

The group are composed of the following gage lines. (See Fig 1 for location.):

Group 1—Nos. 1, 2, 3, 23, 24, 25.
Group 2—Nos. 7, 8, 9, 14, 15, 16.
Group 3—Nos. 6, 13, 21, 30.
Group 4—Nos. 124, 125.
Group 5—Nos. 110, 120, 127, 135, 137.
Group 6—Nos. 101, 102, 103, 111, 112, 113.
Group 7—Nos. 131, 132, 133, 138, 139, 140.
Group 8—Nos. 31, 32, 33, 34.
Group 9—Nos. 5, 12, 22, 27, 28.
Group 10—Nos. 126, 134.

The actual observed unit deformations for the various groups are shown by the "X" curves in Figs. 3-9. These are corrected for temperature changes in the extensometer, but not for temperature changes in the floor itself. If we consider Fig. 3, for instance, comparing the X curve (actual unit deformations) with the temperature curve we note that the two are generally similar. When the temperature falls the steel stress decreases and when the temperature rises the steel deformation increases. This is contrary to what our reason tells should be the case and it becomes necessary to make corrections for the change in temperature of the floor itself.

Temperature Effect on Deformations.—If we conceive of a loaded reinforced concrete slab resting on a frictionless support and further consider that the temperature falls 10° F. we know that while the stress in the steel remains practically unchanged the measured unit deformation of the steel would decrease approximately .00006, the coefficient of expansion for reinforced concrete being approximately .000006 per ° F. In other words, while the moment of the external loads and the calculated steel stress remain unchanged the actual unit deformation will be decreased by the contraction due to the change in temperature. If, however, the slab is a part of a reinforced concrete building the contraction will be resisted by the stiffness of the columns and the actual decrease in unit deformation will be less than .00006. The significant figure is not the actual change in unit deformation, but rather the difference between the actual change and the amount .00006, which would have occurred had the slab been free to contract. This difference measures the amount of the resistance to contraction and gives the actual change in stress. In Figs. 3 to 9 the unit deformation that would have occurred in a body free to contract is plotted in the curves marked "Y," being calculated from the observed unit deformation at the beginning of the test, the change in temperature and the coefficient of expansion of reinforced concrete, .000006. These Y curves represent the unit deformations that should have occurred due to the change in temperature alone and neglecting the resistance to free contraction afforded by the columns and also the effect of other tendencies due to long continued loading that will be discussed later. The difference between the X curve and the Y curve is the change in unit deformation that measures a change in actual stress (neglecting changes in the modulus of elasticity). These differences are plotted in the "Z" curves of Figs. 3-9 and these Z curves are the final data of this test.

Effect of Long Continued Loading.—Laboratory tests of concrete specimens under long continued loading have been made since this test of the Schwinn Bldg., and the results of some of those tests are very valuable in interpreting the data of this test. At the time of making this test the effects of long continued loading on concrete deformations were not appreciated and tests of auxiliary specimens under long continued loading were not made. The test itself, however, shows these effects in a very striking manner in Figs. 6 to 9. In Vol. XII of the Proceedings of the American Concrete Institute, page 302, Professors Fuller and More discuss "Time Tests of Concrete," giving data which has been made use of in Fig. 10 to interpret data from the Schwinn Building Test. Under a constant stress of 1,150 lb. per square inch these tests of concrete cylinders showed an increase in observed deformation from 21.9 units to 124.5 units in 274 days (Table II, page 303 ibid), while under a constant stress of only 650 lb. per square inch these tests showed an increase in observed deformation from 15.0 units to 42.1 units in 52 days (Table III, page 304, ibid). The increases observed in the test of the Schwinn building were of about the same magnitude. Other tests of less duration have been made which show this same plasticity of concrete.

The direct effect of this phenomena is to render futile any attempt to state stresses in the concrete from the extensometer measurements of the deformations in the concrete in this test. It is possible to indicate the approximate range within which the concrete stresses probably lie. To a much less extent it is undoubtedly true that concrete stresses as derived from observed deformations in ordinary 24-hour extensometer tests of buildings are higher than their true values, since in these tests from 3 to 6 days are spent in placing the increments of load and that amount of time is sufficient, as shown by Fuller & More's tests, for a considerable reduction in the modulus of elasticity of concrete in compression. There is a secondary effect which is also important and which was strikingly illustrated in the test of the Schwinn building. In this test as the concrete in the lower part of the drop and slab adjoining the columns and in the top of the slab at the center slowly deformed under practically constant stress an increase in the deflection and stresses at the center necessarily followed. In other words there was a marked shifting of the moment, increasing at the center as shown by Fig. 5 and decreasing at the support as shown by Groups 1 and 2, Figs. 3 and 4.

Summary of Actions in Time Test.—To sum up briefly the foregoing, without attempting an exhaustive statement it seems that the principal tendencies to action operating in this test are as follows:

(1) A stress induced by the resistance of the columns to the movement of the slab under temperature changes. A fall in temperature results in (1) an increase in steel tensions; (b) a decrease in concrete compressions; (c) a decrease in deflections.

(2) An increase in the deformations in the concrete due to the plasticity of concrete under long continued loading, the increase being more rapid at first and gradually decreasing in rate.

(3) A shifting of the moment due to (2) resulting (for the conditions of this test) in a decrease of the moments at the supports and an increase in the moment at the center.

These three tendencies do not, of course, always act in the same direction or to the same result and it is interesting to study the effect of the various actions as shown by the plotted test data (B curves); (2) and (3) apparently dominate the situation. It is also significant that all the actions tend to increase the steel stress at the center under the condition of falling temperatures.

Discussion of Curves.—A brief statement of what the Z curves show graphically as to the deportment of the deformation at various points may be useful here.

Group 1 (Fig. 3) and Group 6 (Fig. 6)—steel and concrete immediately adjacent to wall column capital. The tension in steel shows very little change through the year, the tendency being for the stress to decrease. The compressive deformation of the concrete shows a big increase. During the first 16 days the increase was very materially offset by the decrease resulting from the falling temperature.

Group 2 (Fig. 4) and Group 7 (Fig. 6)—steel and concrete immediately adjacent to interior column capital. The stress in the steel shows a material decrease during the first 5 months of the test, with very little change in the last 7 months. The compressive deformation behaved much as Group 6 above.

Group 3 (Fig. 4) and Group 10 (Fig. 8)—steel and concrete across direct bands at center. After 8 days the steel stress remained very nearly constant throughout the year. The concrete deformations were relatively small also and in general similar to Groups 6 and 7 above, but on a reduced scale. The general behavior of Groups 3 and 10 was like that of Groups 1 and 6.

Group 4 (Fig. 5) and Group 8 (Fig. 7)—steel and concrete at center of span of diagonal bands. During the first six months the steel stress increased and thereafter remained practically constant. The compressive deformation in the concrete increased very little during the first 74 days of falling temperature, but with the turn in the temperature curve increased much faster during the next six months. In the final four months of nearly constant temperature the increase was very small.

Group 5 (Fig. 5) and Group 9 (Fig. 7)—steel and concrete at center of span of direct bands. These groups show much the same behavior as Groups 4 and 8 above, but with much smaller deformations in the steel.

Comparison with Fuller & More Tests.—Figs. 2 and 9 are not plotted to any consistent scale so far as time is concerned (the time is stated but the intervals between readings are not to scale) and Fig. 10 has therefore been plotted to enable a comparison to be made between the data of Fuller & More's tests and that presented herewith. In this figure "a" represents the data of a cylinder loaded to 1,150 lb. per square inch constant load, "b" a cylinder loaded to 650 lb. per square inch constant load, and "c" the compressive deformation at the panel center in the Schwinn building. All three are plotted to the same scales. The striking agreement in the increase in deformation for corresponding periods of the tests is shown by the following comparison:

Curve	Period considered	Unit deformation Beginning.	End.	Ratio.
a	1 to 230 days	.00053	.00280	1:5.28
b	1 to 230 days	.00010	.00052	1:5.20
b	1 to 55 days	.00040	.00105	1:2.62
c	1 to 55 days	.00010	.00024	1:2.40

General Conclusions.—Conditions were exceptionally favorable, both as to the test building and as to recurrence of the same temperature at beginning and end of the test. Only one panel was loaded and other loadings may give somewhat different results. The readings taken during the year were limited to those gage lines which showed maximum stresses in the 24-hour test and the results given here are maxima rather than averages for the various groups. With the conditions of the test in mind certain conclusions seem warranted.

1. The stresses in the steel show practically no change during the last four months of the test (249 to 379 days).

2. The concrete deformations show progressive increase during the year. The average increase of the five groups was much more marked in the first five months (1 to 165 days) than in the last seven. This increase in the average compressive deformation is in accord with experiments on cylinders under laboratory conditions.

3. There occurred a shifting of a portion of the moment during the first six months of the test, stresses adjoining the columns decreasing while those at the center increased. This action must be considered in establishing design coefficients.

4. The increase in the total moment, negative and positive, figured from the steel stresses, was relatively small. While not subject to exact calculation this increase appears to have been considerably less than 10 per cent for the year, with no increase in the last four months.

5. Comparison of the data of this test with that secured by Professors Fuller & More, leads to the conclusions that the actual maximum compressive stresses at the center of the panel were not in excess of 350 lb. per square inch at the full test load.

6. Both concrete and steel stresses at the end of the year appear to be materially less than those to be expected under the Chicago ruling governing the design of flat slabs.

7. This test, taken together with other time tests of concrete in compression, would indicate that the reported values of the compression in the concrete in previous extensometer tests of flat slab buildings are somewhat in excess of the true stresses actually present in those tests. This applies especially to the final readings when the full load has been in place for 24 hours.

ESTIMATING CURVES FOR STEEL BRIDGES.

The estimating curves shown as Figs. 1 and 2 are taken from a recently issued Bridge Manual prepared under the direction of Mr. John H. Lewis, State Engineer of Oregon, for the State Highway Commission. They are intended for handy reference, to determine within reasonable limits the approximate quantities or weights of the materials which enter into the construction of the types of bridges for which the curves were prepared.

The diagrams are based on through Pratt bridges, designed according to the standards of the Oregon State Highway Department for the loadings given.

They are in no way intended as a substitute for careful estimating when the question of any crossing enters the contract and construction stage. The final estimates should always be made up at headquarters on accurate plans and details worked out for the particular bridge in question to cover any special conditions.

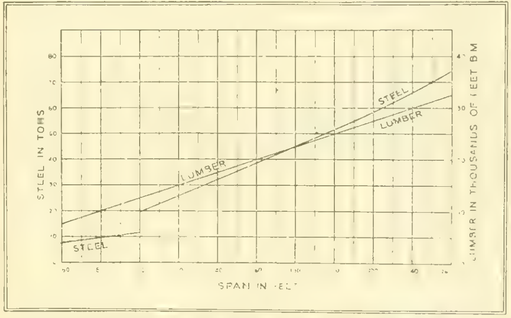


Fig. 1—Quantity Estimates for Medium Traffic Steel Bridges.

Men in the field, however, are often called upon to prepare an estimate on short notice upon which definite construction programs may be authorized without further delay. After the quantities of materials are obtained, prices and labor costs can be judged in the field on the basis of local conditions, perhaps better than anywhere else, and the rough estimate be made up in a short time.

The curves give the weight of steel in both medium and heavy traffic bridges of spans ranging from 60 to 260 ft.

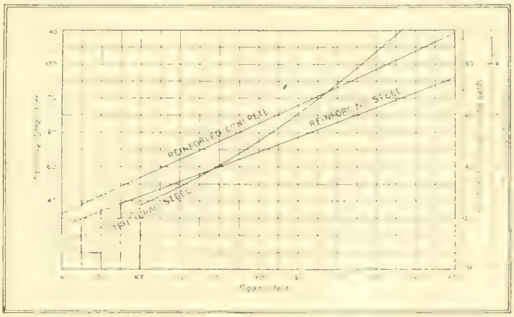


Fig. 2—Quantity Estimates for Heavy Traffic Steel Bridges.

The bridges are of the pony or low truss type, from 60 to 90 ft., and through Pratt trusses from 100 to 260 ft.

Roadways are taken at 16 ft.

Live loads for medium traffic were assumed at 60 lb. for spans up to 150 ft., and 50 lb. for spans over that length. Resultant live load stresses in the trusses were increased for impact.

For heavy traffic the live loads were assumed at 100 lb. for spans up to 150 ft., and 75 lb. for greater lengths, the loads given including provision for impact.

Medium traffic bridges are designed for wood floors and joists; heavy traffic bridges to eventually carry a concrete floor.

DRY DOCK CHARACTERISTICS AND DESIGN.

Characteristics of dry docks for capital ships and details of their fittings and equipment were outlined by Naval Constructor S. M. Henry, U. S. Navy in a bulletin issued last January by the U. S. Bureau of Construction and Repair. This memorandum covered the views of the Bureau in regard to the above points. The subject was considered with special reference to the proposed dry dock No. 4, Norfolk, Va., but the characteristics and requirements are in general applicable to all dry docks. The memorandum is printed in the April issue of Public Works of The Navy, from which the matter following is taken:

Dimensions of Dock.—The dimensions of the dock are based on the docking of any ship that can pass through the Panama Canal, making provision, therefore, for a ship of rectangular cross section 1,000 ft. long, 110 ft. beam, and 40 ft. draft.

Length of Dock.—The length of the dock should be such as to provide 1,000 ft. clear of obstruction, measured between the head of the dock and the inner side of the caisson when in the outer seat.

Width of Dock.—As in the case of the length, the width of the dock is based on a vessel of rectangular section, which is very closely approached in the latest battleship designs. While a beam not in excess of 109 ft. can probably be handled through the Panama Canal, the dock provision is slightly in excess of this, making allowance for a ship of fully 110 ft. beam, with a 3-ft. clearance at the turn of the bilge when the vessel is in dock. As the height of blocks had been increased to 5 ft. 6 in. above the floor, while the sill stands only 2 ft. above the floor, it will be possible to dock a vessel of approximately 42 ft. 6 in. draft by removing the blocking above the sill. The width of the dock at the entrance should therefore be 110 ft. at a depth of 42 ft. 6 in. below mean high water.

Depth of Dock.—The depth of dock below mean high water should be 45 ft. 6 in. to the floor and 43 ft. 6 in. to the sill, these depths being arrived at on the basis of docking a vessel of the greatest draft that can pass through the Panama Canal at mean high water without the removal of any of the regular blocking and of being able to increase the draft at which vessels can be docked by the removal of blocking to 42 ft. 6 in. It is possible that the larger ships may be able to float at a draft in excess of these figures, but the main naval bases can hardly hope to carry a greater depth than 40 ft. in the channels up to the yards, and in such extreme cases provision must be made by temporarily adjusting the trim or making repairs to reduce the draft to these figures.

Caisson Seats.—In addition to the two seats usually provided at the entrance to the dock, an intermediate seat for docks 1,000 ft. in length can advantageously be provided in order to permit the use of a portion of the dock for extended repairs while utilizing the remainder of it for current work, at the same time reducing the volume of water that must be removed in operating the dock. It is difficult to fix any point for the location of the intermediate caisson which will not be open to objection, and on account of the expense and complication due to the fitting of a number of seats not more than one seems justified. Large docks of this type are intended primarily for the docking of capital ships. Where provision is made for docking a battle cruiser, there will not remain a sufficient length of the dock to be utilized for other purposes, so that so far as an intermediate caisson is concerned it is of no value when considering battle cruisers unless a length in excess of 1,000 ft. is adopted for the dock. The present designs of battleships do not exceed 650 ft. in length, nor do any other naval vessels other than battle cruisers, so the division that appears most advantageous is to divide the dock into a 650-ft. length and a length 350 ft. less the beam of the intermediate caisson. By putting the shorter section at the head of the dock there will be available a dock of approximately 325 ft. in length which can be used for much miscellaneous docking of small vessels, caissons, derricks, towing targets, and other craft not exceeding the length, where they are to remain in dock for a considerable period, thus releasing the smaller docks for current work. This will leave the main outer section sufficient for any present ships but battle cruisers, and the time of pumping and flooding will be materially reduced.

Caissons.—The main and intermediate caissons should be duplicates, so as to be available for use in both locations. The caissons themselves should be as simple as practicable, eliminating all valves for flooding the dock, and capstans; the machinery consisting of only the pumping and flooding equipment for the caissons themselves. The deck should be sufficiently wide to furnish an efficient bridge for trucking and for the crossing of employes. Provision for railroad crossing should be provided if the yard system makes it desirable.

The pumping equipment of the caisson should be electrically operated, to obviate the necessity of operating a separate boiler plant, and should be of sufficient capacity to empty the caisson in approximately 15 minutes and to require not over 5 minutes for raising the caisson after the dock is flooded. The most economical section of caisson that will meet the working conditions is desirable. This generally can be obtained not by a broad shipshape section but by the flat section with greater width toward the bottom, so as to afford room for ballast, depth of girder for strength, and to improve the stability, the section being considerably reduced in width for the upper portion of the caisson; reducing the water planes at the depth at which the caisson floats, thus shortening the time of lifting.

If the caisson must be handled a considerable distance from the mouth of the dock, it may be necessary to fit capstans on it, otherwise it can be handled by the capstans at the mouth of the dock, and they may be omitted from the caisson. A chock should be fitted near, but not on the center line of the caisson for taking the stern line from a vessel in dock, for use in finally adjusting its position prior to landing.

Pumping.—The pumping equipment should be electrically operated on the primary voltage of the yard system, and should have a maximum capacity sufficient to empty the dock in approximately one and one-half hours when unoccupied. The pumping plant should be divided into units so as to prevent the complete disabling of the plant, and should be equipped with hydraulically operated valves for quick action. In addition to the main pumping plant there should be the usual drainage pumps and the sanitary ejecting equipment required in connection with the new sanitary lines.

Flooding.—Saving in the time of flooding is of equal importance with saving in the time of pumping, and can be obtained much more readily. Docks should be flooded through a number of openings spaced at intervals along the bottom or sides so that the velocity of flow can be kept to any desired figure. The total time of flooding should not exceed 30 minutes; this time being obtainable without any undesirable velocity of flow. The valves for flooding should be operated hydraulically both for quickness in the normal working of the dock, and as a safety protection in case an accident should make it necessary to stop quickly the flow of water.

Cross Sections and Arrangement of Altars.—With the great width of dock required for the largest vessels it is desirable to reduce the number of altars in the side of the dock to the smallest number necessary for its operation, thus reducing the over-all width of the dock. Any greater width at the top than is necessary increases the reach of the dock cranes necessary to plumb the center, and therefore makes more difficult and expensive the providing of the necessary weight handling appliances, and adds to the total volume of water in the dock which must be removed. Three altars appear to be all that are required. The upper altar should be located about 1 foot above mean high water to furnish a walking platform for getting on and off of floats, and into boats, for handling shores and for making connections to the various pipe and electric lines, with outlets in the dock. The other two altars are required for taking the ends of shores and should be located with reference to the top of the keel blocks; the lower of the two 18 ft. above the line of the keel blocks and the upper 24 ft., the lower being based on taking ends of shores for destroyers and the upper for such larger vessels as require shoring. In addition to these three main altars a low altar at the bottom of the dock raised about 6 in. above the floor of the dock is desired to give a drier walking space than can be obtained on the floor of a dock. Each of the altars should be 3 ft. in width; a less width than this furnishes an insecure working platform.

Transversely and longitudinally the floor of the dock should be horizontal, though sloped locally to the drains for carrying off mud and water.

Tunnels for Pipes and Wires—Outlets.—In view of the very considerable amount of piping and wiring required in connection with the dock a piping and wiring tunnel is desirable. This should extend all the way around the dock and contain the piping and wiring, the outlets to extend through the face of the dock above the highest altar, preferably 3 to 4 ft. above the altar so as to be at a convenient height for making connections, but in every case above the highest high tide to prevent water from entering pipes or tunnels.

Keel Blocks.—The keel blocks should extend for the full length of the dock on 2-ft. centers, with a uniform height of 5 ft. 6 in. The lower course of blocks may be replaced by raising the floor of the dock a corresponding height, the raised portion being the width equal to the length of the individual blocks. Cast-iron blocks are equally satisfactory for the lower three courses; the disadvantage in their use being their high original cost. Whether cast-iron or wood blocks are used, there should be a pair of wedge blocks in each set so that the cap blocks may be removed when required, in making repairs to vessels, without splitting them out. Owing to the heavy pressures on the more recent ships for a distance forward of the knuckle, solid blocking should be built up for a length of 50 ft. commencing at a point 75 ft. forward of the inner sill.

In order to make convenient movement from one side of the dock to the other when the vessel is on the block a set of blocks should be omitted at intervals of approximately 150 ft.

Docking Keel Blocks.—For the distance from 200 ft. from the head of the deck to 160 ft. from the gate there should be two rows of docking keel blocks on each side of the center line, arranged so that they may be placed at any points in and in-and-out direction between the following extremes: Outer end of the top block in extreme out position 46 ft. from center line; inner end of top block in extreme in position 6 ft. from center line.

For the distance from 75 ft. from the head of the dock to 200 ft. from the head of the dock and from 75 ft. from the gate to 160 ft. from the gate, there should be one row of docking keel blocks on each side of the center line, arranged so that the blocks may be placed at any points in an in-and-out direction between the following extremes: Outer end of the top block in extreme out position 27 ft. from the center line; inner end of top block in extreme in position 6 ft. from center line.

The blocks in both of the above cases to be placed on 4-ft. centers, coinciding with every second main keel block.

Bilge Keel Blocks and Gear for Operating Them.—The bilge keel blocks should be spaced on 12-ft. centers coinciding with every third docking keel block, and extending the same length, starting 75 ft. from the head of the dock and ending 75 ft. from the gate.

The chains for operating the bilge blocks should be amply long to permit hauling the blocks from the outside of the dock. When not in actual use these chains should stow below the first altar. This will require a row of chain hooks just below the coping and another row just below the first altar. By stowing the hauling chains on the lower row the first altar will be free from serious obstruction except while actually docking a vessel requiring the hauling of bilge blocks.

Cranes and Transportation.—It is desirable to have provision for a relatively heavy traveling crane which can plumb the center of the dock, with an auxiliary of less capacity and greater reach. Fifty tons is a satisfactory capacity for the main crane. This crane should be electrically operated with an underground trolley connection, and should be so constructed as to permit the handling of standard-gage railroad equipment under it. This arrangement can be obtained by three lines of standard-gage track with an over-all gage of 30 ft., the nearest rail to be 7 ft. from the edge of the dock. This permits the standard clearance between railroad equipment and locomotive cranes and the life rail around the dock.

Stairs.—Stairs into the bottom of the dock should be provided at at least three points on each side, and can best be arranged, in view of the great depth of the dock and the straight sides, by flights leading to points some distance away from the coping of the dock. In addition, auxiliary landings will be necessary connecting to the two middle altars.

Elevators.—A comparatively high speed hydraulically operated elevator for passengers and light freight is desirable in order to shorten the time used in getting into or out of the dock and to save the fatigue involved due to the very considerable depth of the dock.

Slides and Chutes.—The usual form of timber slides should be omitted, owing to the obstruction which they cause in the altars, and further to the fact that the sides of the dock are so steep as to make a slide of doubtful value. The large material can be handled by the dock cranes and the lighter and smaller materials with the elevator. A chute for small timber should be arranged alongside of the stairways for the purpose of sending down into the dock short shores, planking, etc.

Air Lines.—It is necessary to have the yard air system arranged so as to permit operating a large number of pneumatic tools in connection with work in dock. In order to reduce the amount of hose required in connection with this work there should be a 4-in. distributing main with outlets through the sides of the dock on both sides, below the coping, in a convenient position to be reached by the men from the highest altar. In addition to these two mains a 3-in. main along the bottom of the dock is desirable, which should be located so as not to afford any obstruction to the handling of material or the free movement of the working force, preferably embedded in the floor of the dock. Outlets should be placed at frequent intervals, not over 100-ft. centers, in all three lines, permanent manifolds not being necessary. The dock, as a whole, should have a 6-in. connection to the yard air system.

Fire and Flushing Lines.—Fire and flushing connections should be provided, connected to the regular yard fire system. The most convenient access to both of these systems is from the highest altar inside of the dock. This eliminates obstructions in the vicinity of the dock. A 6-in. main on each side of the dock should be fitted with outlets spaced 100 ft. apart. This system will supply water to ships in dock for fire and sanitary purposes by connecting to ships' deck plugs with standard fire hose.

Fresh-water Lines.—It is desirable to have fresh-water lines with outlets along the highest altar for supplying fresh water to ships while in dock. This is necessary in refilling ships' tanks and for testing purposes. The outlets should be at the same intervals as provided in the case of the air and salt-water systems.

Steam Lines.—At times vessels in dry dock have no source of heat, owing to their boilers being out of commission. Where the general layout of the yard is such as to make it feasible, it is desirable to have steam pipes with outlets in the dock so as to be able to supply steam. The only alternative is the providing of portable boilers, which is objectionable.

Electric Lines.—Electric outlets inside of the dock with access from the highest altar should be provided so as to furnish current for the lighting system for the dock itself and current for supplying ships in dock when their own plants are not in operation. The different services require that both alternating and direct current lines should be available.

Lights.—High-power lighting units, so that work can be carried on on vessels in dock, should be provided, as much of the system being permanent as possible. This is practicable with the present efficient high-power gas-filled lamps, though it will be necessary to provide a portable lighting system for work under the bottom of vessels, which can be readily attached to the permanent system.

Sanitary Discharge Lines.—Sanitary discharge lines should be provided, so that all of the ship's sanitary arrangements may be used while vessels are in dock.

Capstans.—Electrically operated capstans should be provided, one at the head of the dock, one at each side of the entrance of the dock, and one at each side of the intermediate caisson seat in large docks where such intermediate seats are provided. The capstan at the head of the dock and the two at the entrance must be capable of a speed sufficient to take the slack of the lines at any rate at which vessels are liable to be handled, while going either in or out of dock. The arrangement should be such as to have all of the machinery of the capstan located below the level of the street. The drum of the capstan must be designed so as to prevent lines riding off when they tend upward to the decks of high-sided ships. The characteristics of a direct-current series motor with provision against running away best meets the requirements of the service. A maximum speed of not less than 200 ft. per minute is desirable, with a reduction in speed when the load is increased. The shifting of gears is undesirable, and the variations of speed and pull should be obtained without the use of gears.

It has been suggested that towing engines somewhat similar to those used for hauling vessels through the Panama Canal locks might be used for handling vessels into and out of dock, replacing capstans.

Bollards.—Bollards are required at relatively close intervals on each side of the dock, and should be spaced approximately 50 ft. apart in order to reduce the time required for shifting line, the general practice being to have two lines at the bow and two at the stern of a ship, and to shift them alternately from bollard to bollard as the vessel moves into or out of the dock, casting off only one line of each pair at a time. The bollards must frequently be located between the dry dock crane rails, and must be sufficiently low to permit the cranes to pass over them. Provision must be made to prevent lines riding off the tops of the bollards and for preventing lines slipping when heavy pulls are brought on them. This can be done by having a pin about 2 in. in diameter through the bollard near the top, the bollard being bell shaped below the pin to prevent lines from jamming.

Cleats.—Heavy cleats, about 42 in., should be fitted along the coping on each side for making fast various lines, also for stowing the docking lines when vessels are in dock. It would be desirable to have no projections above the coping to foul lines in handling ships, but these can not all be eliminated. The life rails are to heavy to move far, so that the cleats do not add a serious obstruction. Such cleats as are necessary for handling the lines used for hauling in and out the caisson should be fitted.

Hand Winches and Hand Capstans.—Hand capstans are desirable in connection with centering vessels. These should be placed on the same line as the bollards, at approximately 100-ft. intervals, intermediate between bollards and not to replace any bollards. With these hand capstans required in connection with centering large vessels, the necessity for the hand winches which were formerly placed along the coping of the dock disappears, and they should be omitted.

Chocks, Fair-Leaders, and Snatch Blocks.—It is desirable to eliminate these fittings as far as possible. If the head capstan can be placed so as to obviate the necessity of a fair-leader or snatch block, it is preferable. If any such fitting is necessary in connection with the headline, a permanent fair-leader is preferable to a snatch block, owing to the difficulty of handling a snatch block of the size required in connection with a large headline. Until a satisfactory fair-leader can be designed, a snatch block must be used for the headline, and ringbolts must be provided. The difficulty with a fair-leader is the tending of the line sometimes up, sometimes down, and to one or the other side. A tilting capstan might be designed that would insure the line tending properly under all conditions. Snatch blocks are generally required in connection with handling the caisson, and ringbolts for use in connection with these snatch blocks are necessary.

Ringbolts, Eyebolts and Special Fittings.—These fittings are required wherever purchases or snatch blocks are to be attached and must be provided in connection with the handling of the caisson and for taking the shore end of the centering tackles. Ringbolts or eyebolts are required at intervals along the bottom of the dock for the purpose of securing staging, horses, etc., when the dock is flooded. A special form of combined hook-and-eye bolt is used in place of small cleats along the face of the dock for securing small lines for boats, floats, and shores.

Life Lines.—Life lines are objectionable in many ways, but on account of the liability of accident are necessary around the edge of the dock and should be arranged so as to be removable with the least work. At the steps pipe rails are preferable to chain life lines. Where chain life lines are fitted, solid stanchions should be used.

Fenders.—With large straight-sided ships, there is danger of the bilges striking the entrance on sides of the dock when the vessel at the water line is still clear of the coping. As a slight touch may result in chipping the seating or in damage to the bilge keels or the hull of the vessel, there would be an advantage in the fitting of permanent heavily constructed wood fenders at the mouth of the dock extending to within approximately 57 ft. of the center line of the dock on each side which would furnish a rubbing surface if ships should touch and would prevent any lower point from hitting the dock. Such fenders should be located at or slightly below the high-water line in order to prevent damage to scuppers and other outboard fittings when using the dock at low water.

Centering Battens and Section Marks.—Provision should be made for centering battens at each caisson and at the head of the dock, and section marks at intervals along the sides of the dock to assist in accurately locating the ship.

Rudder Well.—A rudder well is rarely required in a large dock. There still exists, however, certain types of merchant vessel that can not unship their rudders without dropping them into a well or pit. For this reason a well should still be provided, located on the center line of the dock, the after end of the well 26 ft. forward of the inner sill; the well itself 18 ft. long and 7 ft. wide.

The Pennsylvania R. R. has had plans prepared for improvement at Baltimore, Md., calling for an expenditure of $14,000,000. The work includes the construction of two tunnels, the duplicates of the present tunnels of the Philadelphia, Baltimore & Washington R. R. One tunnel will be east of the Union Station and the other will be west. When completed the Pennsylvania will have a 4-track line through the city.

A grain elevator to cost $3,500,000 will be erected at Canton, near Baltimore, Md., for the Pennsylvania R. R.

METHOD OF CONSTRUCTING CONCRETE LANDING FLOATS AT U. S. NAVAL STATIONS, NEWPORT, R. I.

Two reinforced concrete landing floats have been in use at the Naval Station, Newport, R. I., for over two years and are stated to have shown decided advantages over either steel or modern floats in their lower cost of upkeep and their general superior service ability. A description of these floats and the methods employed in their construction are given in the March-April Professional Memoirs by Civil Engineer Kirby Smith, U. S. Navy. The matter that follows is taken from Mr. Smith's article.

The floats are practically identical in construction and are shown in general dimensions and detail in Fig. 1. They are 40 ft. in over-all length, 15 ft. wide, and 5 ft. 10 in. deep. All concrete is 4 in. thick, heavily reinforced. The floats are divided into eight compartments by one amidships longitudinal and three transverse bulkheads. The latter are without openings, while the former has a square opening 15 in. by 18 in. between each transverse pair of compartments. The bottom of these openings is 2 ft. from the bottom of the float. Access to the interior is had by four deck hatches. The floats are held in place by four 2¼-in. round galvanized iron yokes traveling on braced guide piles. The exterior is protected from abrasion and shock, due to direct impact by boats and other objects coming alongside, by a heavy fender system of long-leaf yellow pine held in place by bolts through the concrete.

The floats were constructed at the coal depot, Melville, R. I., near the water's edge, as shown in Fig. 2. The launching slides, two in number, 12 in. by 12 in., were built first. The lower form timbers, 10 in. by 10 in., were then set up entirely independent of the launching slides. On these bottom timbers the outside forming for bottom and side walls was built. All forming in contact with concrete was 2-in. by 6-in. tongued-and-grooved yellow pine. The general character of the forming is indicated in Fig. 2. All the exterior forming was carried about 6 in. above the height of the deck. When this forming was constructed all reinforcing except that for the deck was placed. Havermeyer's square bars were used. In view of the large amount of reinforcing, it was necessary to exercise the greatest possible care in placing in order that no steel should be nearer the surface of the concrete than called for in the specifications. That the work was well done is evidenced by the fact that no steel appeared at the surface of the concrete in either float.

After placing reinforcing the interior forms were set. These forms were made in a unit for each compartment and were boxlike, without top or bottom, except for a 5-in. strip around the inside at the bottom to insure a near and satisfactory joint between side walls and bottom. These interior forms were suspended from the "A" bracing, as shown in Fig. 2.

A 1:2:3 gravel concrete was used, mixed by a ¼-yd. mechanical mixer. Sand was ¼ in. and down, gravel 1 in. to ¼ in. Both were clean and well graded, resulting in a plastic, free-flowing concrete. Concrete was mixed fairly wet but not sloppy. While no integral waterproofing compound was required, its use was permitted. It was used in both floats; Medusa in the one constructed in 1913 and Kennelly in the other. Forms were oiled just previous to pouring. The concrete was transferred from the mixer to the forms in wheel-barrows, dumped into place and tamped just sufficiently to insure even distribution, absence of air bubbles, and smooth surfaces. The bottom, side walls, and interior bulkheads to the bottom of the deck were poured in one operation, so as to eliminate joints in the concrete below the water line. The forming of the deck was then completed; cleats, hatches, and the steel plate for the lower end of the brow set, and the deck poured. Lampblack was added to deck concrete in order to reduce the glare and the surface troweled.

Water tightness was, of course, the essential feature of the work. Toward this end the integral waterproofing was used and the greatest care was exercised in proportioning and pouring concrete. While the contract called for application of two coats of tar paint to the exterior of the bottom and side walls, it was not desired that water tightness should depend up this protective coating, inasmuch as the float was subject to abrasion. Tests to determine compliance with the specifications as to imperviousness were made therefore before the tar paint was put on. These tests were as follows: 30 days after the concreting had been completed, the float was filled with water and allowed to stand for 24 hours. Dripping and damp spots were marked and the water pumped out. The porous spots were chipped out entirely through the concrete, exposing the reinforcing material. In order to insure a good bond and sufficient holding, the diameter of the hole was increased from both surfaces toward the center. The hole was then filled with a 1:2 cement mortar and allowed to stand for 10 days. The float was again filled with water and damp spots marked as before. On the float constructed in 1913 three such tests were necessary before all signs of seepage disappeared. On the other float only two tests were required. After satisfactory water tightness had been indicated, the float was pumped out and allowed to dry thoroughly, both inside and out. The tar coating was then applied. On the float built in 1913 Cunningham's coal tar paint was used; on the latter float, hot pitch. In both cases two coats were put on. In order that the entire bottom could receive both coats it was necessary to change the location of supports

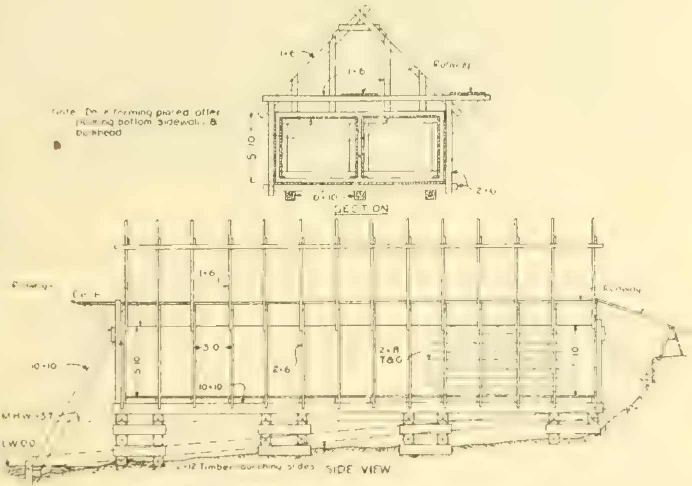


Fig. 1—Method of Construction of Concrete Floats.

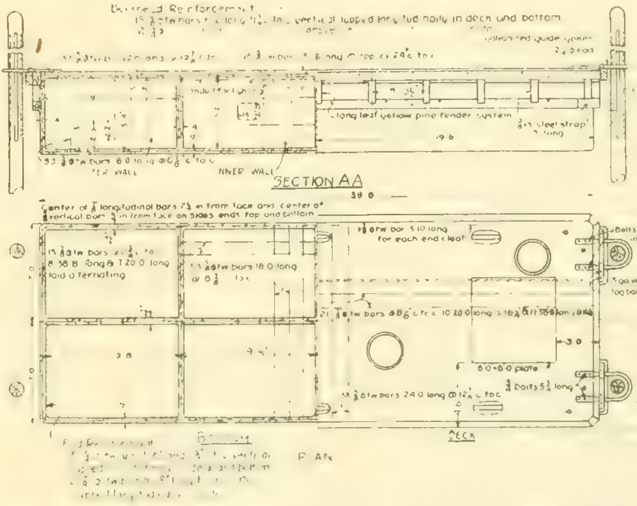


Fig. 2—Details of Concrete Floats.

twice. This involved considerable work, but was of course, essential.

The floats were launched successfully by being lowered with jacks onto the launching ways and hauled off at high water. The bottom painting was protected from abrasion by placing 4-in. by 12-in. timbers between the slides and the float. As the ways were greased, the sliding took place between the ways and these 4-in. by 12-in. timbers between slides and the float.

After placing, inspections were made at irregular intervals. It was found that in all compartments of both floats water accumulated at the rate of about ½ gal. per month in each compartment. Analyses showed, however, that the highest salt content was 0.17 parts of sodium chloride per thousand, indicating that the accumulation of water was not due to seepage through the walls or bottom, but to the condensation of air inside the float due to the difference in temperature, between sea water and air. This difference varied from 11° to 45° during the period that the floats were under observation. That the water in the float is due to condensation is further evidenced by the fact that the under side of the deck is always moist and dripping. The presence of even the small amount of salt in the water can be explained by the leakage around the hatches of sea water blown or splashed onto the deck.

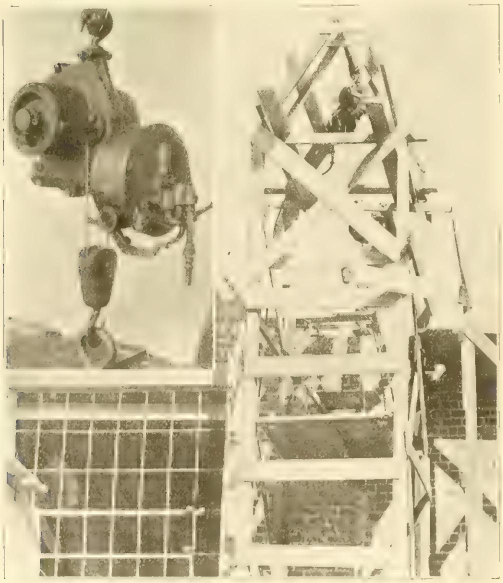
One of these floats was constructed in 1913 at a cost of $2,000 and the other in 1914 at a cost of $2,195.

PNEUMATIC HOIST AND TEMPORARY ELEVATOR SHAFT FOR TRANSPORTING CONCRETE.

Contributed by S. W. Symons.

The transportation of concrete, from the mixer to the work, where the job is so small that expensive concrete handling equipment is not warranted, presents a somewhat difficult problem to the contractor.

One contractor, in the erection of a saw tooth factory building, with a concrete roof, solved the difficulty in a very ingenious manner. A temporary wooden elevator shaft was constructed strong enough to carry 1,000 lb. of concrete, and yet light enough to be easily transported from one saw tooth to another. At the top of this structure a small pneumatic hoist was slung and rigged to haul a cage the length of the shaft.



Compressed Air Elevator for Conveying Concrete to Roof of Building.

REPLACING TRUSS SPANS WITH DECK PLATE GIRDERS WITHOUT USE OF FALSEWORK.

The Pere Marquette R. R. replaced a bridge consisting of four 140-ft. through steel truss spans on a skew with a structure consisting of eight 70-ft. deck plate girder spans, the girders being raised sufficiently to give the same height for waterway. The work was handled without the use of falsework. The methods employed are described by Mr. J. P. Wood, Supervisor Bridges and Buildings, Pere Marquette R. R., in the Proceedings of the last annual convention of the American Railway Bridge and Building Association, from which the following notes are taken:

After building the necessary additional piers, the truss spans were jacked up and cribbing placed at the same time that the filling was being done. After this the old floor beams were cut out and the girder spans placed in the usual manner, the trusses remaining on the cribbing.

When ready to move, the trusses were jacked high enough to clear all obstructions and loaded on two gondola cars, after which they were hauled out to solid ground where they could be dismantled readily.

Replacing Trusses with Girders.

In order to load the trusses securely, four 6-in. by 8-in. wooden posts and two I-beams were used with each gondola. The posts were bolted to the end vertical posts, one on either side, and cut at a length that would carry the truss clear of all obstructions as the lower ends rested on the I-beams which in turn rested on top of the car.

The I-beams were bolted together at the ends and on each side of the posts, to keep them from rolling or canting with the sway of the truss as it was being moved. Two guy lines were also used, one at each end, one end of the line being fastened to the top of the truss and the other end to the car. Because the old bridge was to be scrapped each truss was taken to the same place to be dismantled, thereby bringing all of the same members together and saving time and expense in shipping.

No work train service was required because the derrick car was self-propelling and it had no trouble in handling the equipment and the gondolas loaded with the old trusses. The nearest siding to which it was necessary to go to clear for trains was 1,650 ft. away.

After the truss was jacked up the longest time required for loading, hauling to solid ground and lowering any one of the four trusses to the ground was two hours. The last truss moved required six minutes after it was loaded to move it to the place where it was to be set on the ground. The force employed consisted of a foreman, an assistant foreman, and a crew of from 8 to 10 men, working 10 hours per day at wages ranging from $2 to $3 per day.

This bridge is on a single track line and 12 or more trains are scheduled during the 10-hour working day. The work was completed without a moment's delay to any train. The equipment used consisted of the usual bridge tools, a concrete mixer and a derrick car with clamshell bucket to lift the gravel to the mixer.

THE VALUE OF A TRAINING IN THE HUMANITIES FOR ENGINEERS.*

While there are some conspicuous instances of engineers who have achieved marked success without the advantage of a degree from a technical school, the large majority of practicing engineers have had the benefit of a technical course before beginning their professional careers. In order to make any intelligent suggestions as to the subjects which should be included in such a course of study, it would be well to consider briefly the kind of work the engineer will be called upon to do.

Engineering was formerly believed by the average citizen to be little more than a trade. It was thought that an engineer should be able to use surveying instruments and be able to compute land areas and the volume of a cut or fill or of a mass of masonry. He might be able to build a road, but in this respect he was held to differ very little from the average citizen, who appears to have been born with the conviction that he is as competent to build a road as to serve in Congress.

The engineer's function was conceived to be the planning and carrying out of what others may have concluded to be necessary and expedient. Those who determined what was to be done seem to have felt it to be the duty of the engineer to do things when he was told, as he was told and because he was told. For a long time the engineer himself appeared to acquiesce in this conception of his function. Whether or not a certain project was feasible or timely, whether the type of structure or the material which it was proposed to use was best adapted to the purpose, whether the enterprise would justify itself on economic grounds, whether the plan of financing it was sane and prudent, whether the terms of franchise or concession, if such were involved, would insure adequate protection for the public and at the same time permit a fair return on the capital investment—such questions were not his concern. They would be settled by attorneys, capitalists or the public authorities. The engineer himself was not inclined to assume any responsibility for them; it was his duty to see that the general plans were honestly and expeditiously carried out. While he realized his responsibility for the stability of any structure erected under his direction he had little concern for anything but its physical stability, although he desired assurance that the funds were available to cover his fees or salary.

These were the conditions which prevailed within the memory of most of us, but they do not exist at the present time, except possibly in some branches of the public service, municipal, county, state and even federal. No financial concern engaged in floating bonds for private enterprises will now undertake to handle such securities until they have had a report from competent engineers as to the soundness of the project, including not only its engineering feasibility but its probable earning capacity and the market for its output, whether that be power, light or any manufactured product. Such reports, if they are to carry conviction, must not only be technically sound, but they must be orderly in arrangement, clear and concise in the presentation of facts, arguments and conclusions, and must bear upon their face evidence of the absolute confidence of the writer in the accuracy of his facts and deductions. Further than this, the engineer most frequently present verbal explanations and arguments to the promoters or to a board of directors before the enterprise is undertaken as well as during its progress, if he is charged with its execution. Many reports resulting from thorough and painstaking investigation fail of their purpose because the subject matter is not presented in an orderly manner and the conclusions are not clearly and concisely expressed. Often, too, when the engineer is called before a board of directors and asked for further information the impression which he makes is an unfavorable one, due, chiefly, to the use of poor English and the self-consciousness which comes from lack of confidence in speaking.

The head of a large industrial corporation, who was also the chairman of the board of trustees of an engineering school and was urging the broadening of engineering education, put the case in this way:

> We can get plenty of men who are technically competent who are careful and thorough in their investigations, whose conclusions we know to be sound, but who cannot make a favorable impression before a board of directors. We can get plenty of lawyers, who, after being coached by our engineers, can glibly and even convincingly talk to this same board of directors until some question is asked which has not been covered in the process of coaching, when they, too, will flounder about. If we can secure a man who possesses the conscientious thoroughness and accuracy of the engineer and also has the facility of expression and persuasiveness of the lawyer, what is a salary of $25,000 or $30,000 to us for such a man?

He therefore urged that this particular school, instead of trying to turn out a large number of $2,000 to $5,000 men, give to the profession a limited number of $25,000 to $30,000 men.

What kind of studies are best calculated to fit a man for such a professional career? Let us say that the purpose of his training should be to insure:

(a) Honesty and accuracy in his reasoning.

(b) The habit of thoroughly testing his conclusions in order that they may be not only the logical, but the inevitable, result of his premises.

(c) Clearness and simplicity in his presentation of both premises and conclusion.

(d) Orderly and logical arrangement of both, so that they may readily be followed by those to whom they are addressed.

Personal honesty and high professional ideals are, of course, essential to true success in any occupation, but the course of training in these subjects should begin before a boy is born and we are considering only his professional training after the high school period.

The study of mathematics should induce accuracy in thought and work. An error cannot be tolerated and will inevitably be discovered in the solution of a mathematical problem which, if properly checked, will prove itself. If not so checked and its accuracy proven, the perpetrator of a mistake cannot escape is consequences. Such reasoning, however, is conducted through the medium of formulae and equations which are not understood by the layman for whose benefit they must be converted into ordinary language. If we are to insist, as it will doubtless be admitted that we should, that engineering is one of the learned professions, ranking in dignity with law, medicine and theology, we may also insist upon the desirability of an equally thorough foundation upon which engineering training is to be based.

It will be futile to urge that engineering degrees should be given only as the result of a post-graduate course open exclusively to those presenting arts degrees. While the increasing number of men holding such degrees who come to our best engineering schools is most encouraging, it will be unwise to insist upon this as an entrance requirement. To do so would exclude many earnest young men who possess the natural ability, ambition and industry to achieve success in whatever they undertake, but who have neither the means nor the time for both the arts and engineering courses. What we may properly insist upon is that the courses in our engineering schools be liberalized by the introduction of some culture studies. Dr. J. A. L. Waddell, who has been insistent in urging the broadening of engineering education, said in an address to the Engineers' Society of Western Pennsylvania:

> Thechnical teachers are beginning to awaken to an appreciation of the fact that it has become absolutely essential to instruct their students in other lines than mathematics and technics in order properly to fit them for their life's work, and that American engineering courses will have to be broadened so as to provide thorough instruction in economics, history, oratory, logic, business and other studies of a non-technical nature. Without a good grounding in such lines the engineer of the future will continue to be a narrow technical [illegible] by the community and [illegible] for his [illegible]

I am not taking too literally the subject assigned to me and insisting upon a study of "the Humanities." The term is an old one and its meaning is not quite clear. The Century Dictionary defines the humanities as "including learning or literature of a merely human or secular kind as opposed to divinity, and generally the several branches of such literatures as philology, grammar, rhetoric, poetry, the study of the ancient classics and the like." Professor G. P. Marsh notes that the conviction of the value of these studies as a moral and intellectual discipline has led scholars almost universally to ascribe the origin of this appellation to a sense of their refining, elevating and humanizing influence. He expresses the belief, however, that it is an erroneous etymology, holding that they were so-called in distinction from divinity, the two studies of philology and theology then completing the circle of scholastic knowledge which at the period of the introduction of the phrase scarcely included any branch of physical science. May I not then take sufficient liberty with my subject to insist that engineering courses must be enriched by the introduction of culture studies?

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* An address delivered Dec. 27 before the American Association for the Advancement of Science, by Nelson P. Lewis, Chief Engineer Board of Estimate and Apportionment of New York City.

It is quite probable that familiarity with the classics, supplemented by a thorough course in one's own language, will greatly enrich one's vocabulary, but all of this is not needed to enable an engineer to write an intelligent report or to address a board of directors. It is not necessary that a report dealing with an engineering subject should be expressed in the language of a Howells or a James, nor will its force and that of its conclusions be lessened by the occasional use of a split infinitive or through the employment of a phrase that might give pain to some purists. It will, however, be much more forceful if expressed in simple but virile language, the habitual use of which can be acquired only by the reading of the best literature.

Many of the so-called colleges of liberal arts no longer insist upon Greek and require little Latin on the part of candidates for admission, while Latin is not carried beyond the freshman year except as an elective, although the enforcement of the group system, with one major subject and carefully balanced electives, is calculated to produce a well-educated man, if not a scholar in the old sense. Why should not our engineering schools so modify their curricula as to insist upon a major group of engineering subjects, supplemented by a thorough course in the English language and literature, a good training in, not a smattering of, one other modern language, and courses in history, economics and the law of contracts. But, the technical school men will say, we would not have time to do this unless we shorten or omit some of the courses which we believe to be essential to an engineering education or add another year to our course. Then let them adopt one or the other of these alternatives, and it is quite probable that the records of their graduates would reflect greater credit upon these schools than they have in the past. A number of specific instances could be given of men whose professional training has been along entirely different lines and who have attained conspicuous success as engineers. While these cases may be exceptional, they are sufficiently numerous to justify a reference to them and even to support the plea for liberalizing engineering training.

The 6-year course leading to both the arts and engineering degrees which has been adopted by a number of our universities is most encouraging evidence that engineering is coming to be considered one of the learned professions, and yet for those who can afford the time and money the ideal plan would be to pursue their culture studies in one of the smaller colleges which have not yet gone to an extreme in the adoption of the elective system. A young man will be more likely to attain real culture in such an institution, his interests will be broadened, his life friendships will be among men of various professions and occupations and he will have a better opportunity to find himself and make a wise choice of a profession if that choice may be deferred until the latter half of his college course. The influences and associations of the college campus are distinctly humanizing and, even though he may attach as much importance to athletics as to scholarship, he will have laid an admirable foundation upon which the superstructure of his professional education my be reared. The writer realizes that, while this plan may be ideal, it is beyond the reach of a great majority of those who wish to enter the engineering profession.

Next to this in its advantages may be placed the six years' course leading to the arts and engineering degrees, but even this is too long in most cases, and the greatest number of engineering students will continue to begin their professional courses immediately after finishing their secondary school work.

It is unfair to these young men, it is unfair to the engineering profession, to confine their further education wholly to strictly technical courses. Extend these courses to five years, if necessary, in order to introduce the liberal studies which have been referred to, giving credit to those who present degrees from reputable colleges, so that they may complete the strictly technical work of the curriculum in four or even three years. In other words, it is time that those who are responsible for the training of engineers realized that they are fitting men for one of the learned professions and that this cannot properly be done unless the curriculum is humanized.

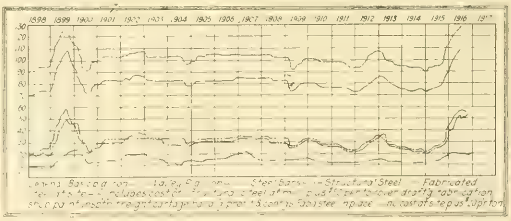
STRUCTURAL STEEL PRICES, 1898 TO 1917.

The accompanying diagram, reproduced from the December, 1916, Bridge Manual of the Oregon State Highway Commission, shows price fluctuations in steel from year to year at various stages in its progress from furnace to the erected bridge. The lowest line in the diagram represents pig iron (Pittsburgh District), the next two lines steel bars and structural steel in the Pittsburgh District, the second line from the top fabricated steel at site (average for Oregon), and the top line steel in bridge erected in Oregon.

The curves representing the costs of pig iron, steel bars and structural shapes are drawn up from data from The Iron Age and are based on prices at Pittsburgh.

The line representing fabricated steel at the bridge site is obtained by adding $50 to these Eastern prices on structural shapes to provide for: Steel inspection, fabrication, shop inspection, waste in fabrication, draughting, shop painting, freight to Portland district, road haul and handling.

While this assumed figure of $50 is not a maximum, it is stated to be considerably higher than the mean or average cost of the sum of the items it is intended to cover, within the present zone of steel bridge construction in Oregon.



Price per Ton of Structural Steel from Furnace to Place in Bridge.

The line representing steel erected in place is obtained by adding $20 to the cost of the fabricated material at the site, to cover all costs of falsework, handling, erection and painting, and is a little better than a fair average price for steel bridge erection in Oregon. This line suggests in a graphical way, for the term of years which it covers, a base line about which, in comparative proximity to it, the prices paid for this work should have ranged themselves. The costs from mill to site and for erection and painting are based on the cost of a large number of structures built in Oregon. The Manual states that actual costs should run under, rather than over, the figures given.

Teaming rates vary considerably according to the topography of the country and condition of the roads. They also are subject to conditions of supply and demand, but, according to the Manual, a fair average price for teaming throughout the state is 30 ct. per ton mile.

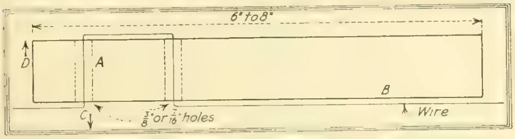
A HANDY TOOL FOR THE REPAIR MAN ON COMPRESSED AIR WORK.

Contributed by H. B. McDermid.

Some time ago the writer was employed in repairing riveting machines and their appurtenances for a gang of riveters on tank work. All the rivets were driven cold, the men were all paid by the piece and strike conditions prevailed. The wear and tear on equipment under these circumstances was very severe, but in no place was it more marked than in the way the fittings were constantly pulling out of the tail or buck hose. We are carrying 110 lb. air pressure on the lines, and this, coupled with rough handling, would pull out fittings some days faster than a man could put them in. All sorts of patent clamps were tried, but none proved equal to this job.

I was about to give up in disgust when one of the gang told me of a tool that solved the problem in the neatest way that I have ever seen during 15 years of construction work.

He took a hammer handle, sawed off a piece 6 to 8 in. long, then bored two ⅜ in. holes through it; the first ½ in. from the end of the handle, the other parallel and approximately 1 in. further up the handle, as shown in the sketch. He then laced a wire of about 16 gage through the holes, as shown below. The wire was pulled through hole A until 4 or 5 in. protruded. It was then clamped in the vise along with the fitting which had been previously forced into the hose, and the wire was then tightly wound over the hose, the tension being regulated by lightly holding the wire against the handle, with the hand at B. The hose may be at C, in which case the direction of rotation is as shown by the arrow; or at D, when the direction is opposite, as again shown by the arrow. Having the wire and hose clamped in the vise, my man commenced to wind the wire down the length of the fitting as tight and close as ever a wire was wound on a spool; then back with three or four turns to the starting point, and there the two ends were twisted together with pliers in the ordinary manner, and the job is done to stay. It is hard to believe what an enormous pull can be exerted on that wire. In fact, the novice at his first attempt will probably pull his wire in two several times before he gets the correct notion of the pull he is exerting. But in no case will the fitting ever again pull out. In hundreds of cases I have never known a blow-out. Neither use, pressure nor abuse has any effect on a joint well made in this manner—the hose always wears out first, before the fitting gives trouble.



Sketch of Tool for Preventing Fittings Pulling Out of Air Hose.

This work was all done on ¾ in. and 1 in. hose, but there is no reason why it should not do for any size, or, in fact, in any place where it is desired to do a snug, tight job of winding wire. The convenience of the tool is further enhanced by the fact that it is cheap, can be made anywhere, any time, by anyone, and can always be depended on to do a tight, neat job.

Highway Bridges in Illinois.—It is estimated that there are 196,000 highway bridges of all types in Illinois. To every mile of roadway in the state there are, on an average, 2.12 bridges, the average length of each structure being 7.76 ft. At the beginning of 1915 more than 33 per cent of the bridges were wooden structures.

The U. S. Government is asking bids for constructing the substructure for the Georgetown-Rosalyn bridge. This structure will have a total length of 1,020 ft., and an overall width of 68 ft.

INDIRECT LIGHTING DESIGN.

The application of the "flux of light" method to lighting calculations was described by Mr. G. Harry Swanfeld of the G. H. Swanfeld Engineering Co., Philadelphia, in a paper presented March 16 before the Philadelphia Section of the Illuminating Engineering Society. An abstract of the paper from the April Proceedings of the Engineers' Club of Philadelphia follows:

The present high efficiency of lamps makes economically possible a system of lighting of comparatively low utilization factor wherein the source of light is entirely obscured and illumination received from the ceiling as a secondary source. This is equivalent to an extended source relatively close to the reference plane. The resultant illumination is of a high degree of diffusion, eliminating sharply-defined shadows and reducing glare from glossy surfaces. There are shadows produced by the predominant downward flux, but they are greatly softened. Even with "indirect lighting" highly-glazed reading pages may cause discomfort.

When it comes to the calculation of installations, while the characteristics of the light source play an important role, knowledge of other factors is necessary.

In fact, what we are most concerned with are the ceilings and walls, since these are the effective light sources. They completely alter conditions. Heretofore the light sources were very small, and, relative to their size, comparatively distant from the surface to be illuminated, ordinarily called the plane of reference. Hence the inverse square law could be applied and reasonably exact computations made by its application. With indirect lighting, conditions are reversed. The effective light source, the ceiling and walls, is large in area and, relative to its size, in close proximity to the plane of reference. Hence the inverse square law cannot be applied. Although the fundamental method of making lighting calculations is to calculate the illumination point by point, employing the inverse square law, another convenient method has come into vogue, known as the "flux-of-light" method. The application of this method is dependent upon the full knowledge of the characteristics of the lighting equipment and its application to different types of interiors. It is a ready means of disposing of the problem of lighting calculations for indirect installations.

The application of the flux-of-light method of calculation assumes an intimate knowledge of the percentage of total light flux available on the plane of reference. This percentage, called the efficiency of utilization, has been worked out under numerous fixed conditions, the results of which are shown in Table I.

TABLE I.*

Dimension factor.	—Efficiency of utilization, per cent†— Light walls. (Coefficient of reflection 0.65.)	Medium walls. (Coefficient of reflection 0.40.)	Dark walls. (Coefficient of reflection 0.05.)
1	0.27	0.17	0.14
2	.34	.26	.22
3	.38	.31	.26
4	.40	.34	.30

$$\text{Dimension factor} = \frac{\text{Minimum dimension of room}}{\text{Ceiling height}}$$

*Table taken from tests conducted by National X-Ray Reflector Co. engineering department

†These values of utilization efficiency apply only for installation in interiors having white or light-cream ceilings (coefficient of reflection about 0.65).

From Table I it will be noted that the efficiency of utilization varies with the proportions of the room. Thus in a narrow high room the efficiency is lower than in a broad low room. The chief reason for this is the greater loss of light in double reflection from the walls.

The color of walls also has an effect on the utilization efficiency. If the walls are dark, but little light intercepted by them will be available on the plane of reference, but if they are light, a considerable increase in efficiency results.

Having knowledge of the utilization efficiency that may be expected under various conditions of everyday lighting practice, the next step is to determine the quantity of luminous flux it is necessary to deliver to the plane of reference in order that the lighting may be satisfactory. This quantity depends on a variety of factors: (1) Dark-colored objects require more illumination than light ones; (2) work requiring close discrimination of fine detail requires higher illumination intensity than, for instance, ordinary reading; (3) for long periods of application high intensities are helpful in reducing eye-fatigue; (4) for rapid seeing high intensities are adequate. From long experience we have come into possession of quite definite knowledge of the illumination intensities required for a variety of purposes. In Table II is tabulated the intensity in foot-candles commonly recognized as satisfactory lighting in a number of types of interiors in which indirect lighting proves ideal. Since the foot-candle is the flux density in lumens per square foot, multiplying the area to be illuminated by the required foot-candles intensity gives the effective lumens which must be delivered to it.

TABLE II.*

Required illumination:	Foot-candles.
Churches:	
Auditorium	2.5- 3
Entrance	2.5
Sunday school room	1 - 2
Hospitals:	
Corridor	¾
Operating rooms	6 -10
Ward	0.5- 1.5
Hotels and clubs:	
Ballroom	3 - 3.5
Barber shop	3.5- 4.5
Bathroom	1.5- 3
Bedroom	1 - 1.5
Billiard room	3.5- 4.5
Buffet	4 - 4.5
Card room	3 - 3.5
Corridor	0.5- 0.75
Diningroom	2 - 3
Kitchen	2.5- 3
Lobby	3 - 4
Lodgeroom	3 - 3.5
Lounging or rest room	1.5- 2
Parlor	1.5- 2.5
Restaurant	3.5- 4.5
Writing room	3 - 3.5
Offices:	
Accounting	3.5- 5
Banking	3.5- 5
Corridors (first floor)	2 - 3
Corridors (above first floor)	0.5- 1.5
Drafting	7.5-10
General	3 - 4
Private	2.5- 4
Stenographic	4 - 5
Stock	2.5
Vaults and filing	2 - 3
Factories:	
Textile mills	6 -8
Sewing rooms	6 -8
Residences:	
Bedroom	0.5 -1
Diningroom	1 -2
Hall	0.25-0.5
Livingroom	1 -2.5
Schools:	
Classroom	2 -3
Classroom (business college)	3 -5
Laboratory	3 -5
Library and reading room	2.5 -4
Museum	2 -3
Stores and salesrooms:	
Dark display	4 -6
Fitting room	4 -6
Light display	3 -5
Theaters:	
Auditoriums	2.5 -3.5
Auditorium (moving picture):	
Dim	0.25-0.5
Bright	2 -2.5
Lobby	4 -6
Miscellaneous:	
Armory	2 -3
Art gallery	3 -4
Courtroom	3 -4
Gymnasium	3 -4
Skating rink	2 -3
Station waiting room	3 -4
Studio	2 -3.5
Telegraph office operating room	3 -4
Telephone exchange	3 -4

*Data taken from Engineering Data Book of the National X-Ray Reflector, Chicago.

Once the amount of primary light flux required is known, the number and size of lamps may be determined from Table III.

TABLE III.*

Vacuum tungsten lamps.		Gas-filled tungsten lamps.	
Lamp size, watts.	Total lumens.	Lamp size, watts.	Total lumens.
10	75	100	1,257
15	128	200	2,795
20	178	300	4,600
25	234	400	6,130
40	381	500	8,060
60	588	750	12,740
100	1,032	1,000	17,960

The choice of the number of units is dependent upon the dimensions of the interior and the character of work carried on. A uniform illumination may be desirable, but in many instances a degree of non-uniformity is permissible.

*Data taken from Handbook on Illumination by the Edison Lamp Works of the General Electric Co.

With indirect lighting the spacing between outlets should not exceed 1.5 times the ceiling height if the illumination on a horizontal plane 30 in. above the floor ("desk level") shall be uniform. Where uniformity of intensity is not essential, greater spacings are permissible, but in extreme cases should not exceed 2.5 times the ceiling height.

As to the length of suspension of the indirect fixture, in the writer's opinion this should be chosen so that the illuminated field on the ceiling from adjoining units overlaps, since this gives the most pleasing ceiling effect. With a properly designed reflector this may be accomplished with ordinary suspensions and without great loss in efficiency of reflection from the ceiling.

FACTORS LIMITING THE PRODUCTION OF RIVETED WORK.

As a result of time studies of a riveting gang consisting of four men—riveter, bucker, sticker and heater—certain factors were found to limit the production. These factors are outlined in the April issue of "The Water Tower," a publication of the Chicago Bridge & Iron Works, from which the following notes are taken:

(1) Waiting for rivets. This in turn resulted from time waiting for heater to throw out rivets to the riveting gang and waiting for heater to get rivets from storage bins. On a certain job ¾ in. by 3 in. rivets were being driven. The job required about 1,200 rivets. After driving for five hours the ¾ in. by 3 in. at the rivet heater's bins were used up. Heater went over to the rivet storage bins and found there were no more ¾ in. by 3 in. rivets in stock. He came back and reported the fact to the riveter, who in turn went to the foreman and told him that there were no more ¾ in. by 3 in. rivets on hand. He received orders to use ¾ in. by 2¾ in. or ¾ in. by 3¼ in. In order to do this the riveter had to arrange for a smaller die or a larger die, depending upon the length which he found to work to the best advantage.

A glance at the time study sheet shows repeated instances of waiting for rivets, for example, after a piece of work had been finished and a new piece clamped in place, there appeared in the time study sheet "Waiting for rivets 2.5 minutes." Why did five men wait 2.5 minutes each? Simply because one boy did not put the rivets in the furnace at the right time. On another sheet in the time study sheet appears the item "Waiting for rivets 5 minutes." The rivet boy watched the riveting gang, turned column over and clamped it, instead of attending to his own business and seeing that rivets were ready to start driving as soon as material was clamped down. Five minutes elapsed between time the work was ready before the first rivet was pitched out. On driving 8,141, post-marked P-2 lattice and cover plate, following is the analysis of the work done:

	Minutes.
Handling	2.7
Driving 39 rivets and taking out 29 bolts	2.5
Driving 114 rivets and taking out 24 bolts	11.5
Waiting for rivets	14.7
Total, 153 rivets in	36.9

This is at the rate of 249 rivets per hour. The schedule calls for 300 rivets per hour. If we deduct 14.7 minutes —waiting for rivets—from 36.9 minutes, the result is 22.7 minutes actually spent in driving this post. This is at the rate of 405 rivets per hour. It is, therefore, evident that the only thing to do, in order that the gang shall make a handsome bonus is to teach the rivet boy to throw out the rivets at the proper time and save the time otherwise wasted in waiting for rivets. Experience proves that the rivet heater has more influence on limiting the production of work than any one factor.

(2) Trouble with dies. The tool steel used in dies will not stand up when driving at the rate of 250 to 300 rivets per hour. It was necessary for the riveter to have a can of water constantly at his side and to quench the dies after driving 20 or 30 rivets.

(3) Work was not properly fitted up. The fact is, a great deal of it was rotten. The fitting gang could not fit up fast enough to keep the riveting gang going at top speed, and the result was that they slighted their work and the material turned over to the riveters was not as it should be. More fitters and better fitters should have been used so that the work, when turned over to the riveting gang, would have been ready to be riveted. As it was, the holes did not match up and required drifting.

(4) The riveting gang had to take out their own bolts.

(5) The riveter could not find the special tools for various classes of work, because of the fact that he had no tool box in which to lock up his tools, with the result that everyone in the shop had access to his tools, and if they wanted anything and his back was turned they

would simply walk away with it, and when he needed that particular tool again he had to go and appropriate it from some one else.

(6) The rivet heating furnace is located on a platform. This caused considerable loss of time in getting rivets, and also prevented co-operation between the heater and the gang, because of the fact that the rivet boy could not always see the work, and it was impossible for the riveter to talk to the boy and give him instructions regarding the work.

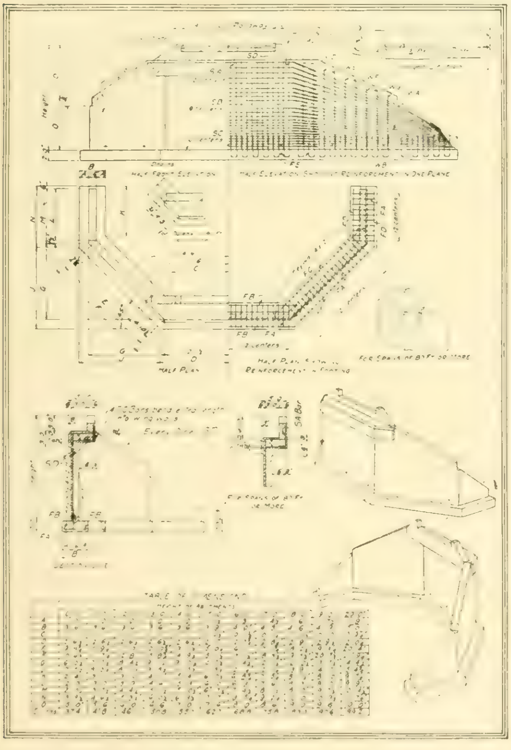
(7) There was insufficient space for the riveting gang to work in.

(8) Finished material was not taken away fast enough.

Most of these causes for slowing up the riveting gang boil down to the one fact that work is started before everything is ready. A job should never be started until you are dead sure that everything is ready to go through with it.

STANDARD REINFORCED CONCRETE ABUTMENT OF MICHIGAN HIGHWAY DEPARTMENT.

An interesting design of reinforced concrete abutment for steel bridges is included in the revised standard plans of the State Highway Department of Michigan. It is stated that the design has made it possible to effect a saving of from 30 to 50 per cent for heights from 20 to 25 ft. above the top of the footings. The drawing shows the design for steel girders with 18 ft. clear roadway and for heights of from 10 to 20 ft. This abutment is suitable for any length of steel span up to 150 ft. For abutments of a greater height than 10 ft. it has been found best to turn back a portion of the ring walls parallel with the roadway. The economy of the design over the cantilever abutment is due to the fact that stability is maintained by the general shape of the footing rather than by the width of the footing at any section.



Standard Reinforced Concrete Abutment for Steel Girder with 18-ft. Roadway.

PLANS AND MATERIAL ESTIMATES FOR HOWE TRUSS BRIDGES.

The covered Howe truss bridge is in quite extensive use in Oregon for stream crossings on secondary highways. It also is in use for interurban transportation on some of the most prominent electric railway systems in the Pacific Northwest. In the recently issued Bridge Manual of the Oregon States Highway Commission, prepared under the direction of Mr. John H. Lewis, State Engineer, it is stated that Howe truss spans, when properly covered, will last from 30 years to upward of 40 years. Additional details regarding this type of bridge abstracted from the manual follow.

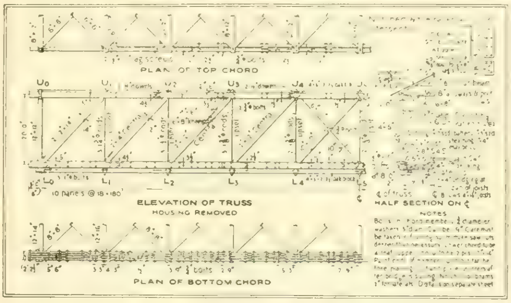


Fig. 1—Standard Plan of Oregon State Highway Commission for Howe Truss Bridge.

Good lumber for bridge timbers is still to be had at points west of the Cascades and at many places in or adjacent to the Blue Mountains of Eastern Oregon for from $13 to $16 per thousand.

Span for span, the weights of material entering into freight and teaming costs are about the same as for steel. These bridges, housed in Western Oregon, where the rainfall is abundant, and open in the dry climate of the eastern part of the State, will give long service.

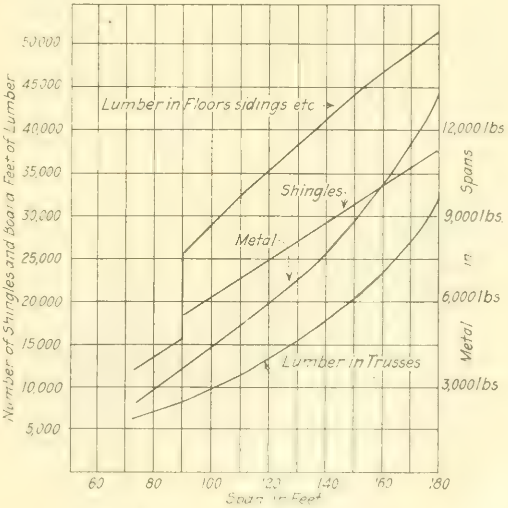


Fig. 2—Material in Howe Truss Bridges.

While they are hardly as rigid as riveted steel trusses, they are nevertheless sufficiently stiff for highway traffic.

Piers and abutments can be put in of concrete adapted to receive steel bridges when the traffic becomes so great as to require a first class bridge or when the old bridges are worn out, as by that time lumber will be worth considerably more than it is today.

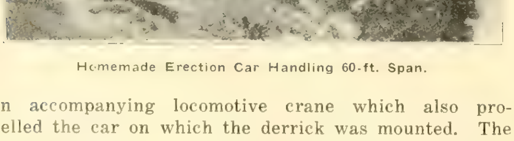
Assuming that the policy is adopted of putting in first class concrete piers and abutments, the first cost of housed Howe truss bridges is as much and sometimes more than 25 per cent less than that of steel. Its life, properly built and subject to the service for which it was designed, will be as long, chiefly, however, to be fair to the steel, because the latter often has not been kept properly painted, no one having taken the trouble to figure up the money loss per year in deterioration.

Against the advantages which have been mentioned should be considered the greater fire risks, difficulty sometimes in getting teams to cross the dark covered bridges at night and the danger of accidents to teams, or especially automobiles, if the approaches are not on a straight line with the bridge for some distance either way. The appearance can be improved considerably over that of some bridges now in existence, at very little additional cost.

The standard plans of the Oregon State Highway Commission for a Howe truss bridge are shown in Fig. 1. The approximate quantities of materials in bridges of this type are indicated in Fig. 2. The curves were plotted from material lists of spans taken at regular 18-ft. intervals, starting with a 72-ft. span and ending at 180 ft. The roadway is taken as 16 ft., and the live load at 75 lb. per square foot, including impact. Under metal are included all rods, bolts, washers, spikes, nails, etc. All spans above 72 ft. are estimated to be covered, and two curves for lumber are given, one for the trusses and laterals only; and the others for materials in floors, siding and roof except shingles. For the latter a separate curve is shown. The curves are intended to furnish a handy reference for determining within reasonable limit approximate quantities.

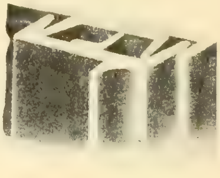
PLACING GIRDER SPANS WITHOUT FALSEWORK.

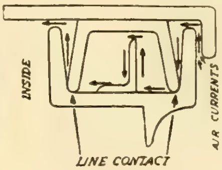
A home-made erection car, rigged up from parts of a truss bridge that was to be erected later, was used on the extension of a railroad for handling girder spans. The arrangement is described by Mr. G. W. Rear, General Inspector Southern Pacific Co., in the Proceedings of the last annual convention of the American Railway and Bridge Building Association. The boom was the lower chord of a truss span and extended nearly to the rear of the car. The backstay was a plank or vertical post and the forward stay was built of counters. The A-bent was built of timbers. Power was taken from an accompanying locomotive crane which also propelled the car on which the derrick was mounted. The car and derrick were counter-weighted with rails. All of the girder spans on the line were set with this device without the use of falsework. The cost of rigging up and dismantling the car was $66, a very small item of expense as compared with the cost of falsework which was saved. The car was built by the late F. S. Edinger, a member of the American Railway Bridge and Building Association, and greatly reduced the cost of girder erection.


Homemade Erection Car Handling 60-ft. Span.

A VERTICALLY-SLIDING SOLID STEEL WINDOW.

A type of vertically-sliding steel window, having a line contact with the sliding portion of the sash, has been placed on the market recently by the Detroit Steel Products Co., Detroit, Mich. In this type the danger of sticking, binding or rusting is claimed to be eliminated by the use of a channel section in the flaring sides which forms a line contact instead of a flat surface contact. The insertion of an angle attached to the sliding section of the sash and protruding into the center of the channel guides, causes the air currents to change their directions 10 different times before entrance to the building is obtained. The windows can be readily screened, washed and shaded, and can be operated easily owing to the line contact and because the connecting chain passes over an unusually large roller bearing pulley. It is stated that 2 to 3 lb. pressure is all that is required to move the windows.


Channel Section.



Contact and Direction of Air Currents.

PERSONALS.

J. G. Scrugham, dean of the Mechanical School of the University of Nevada, has been appointed State Engineer, succeeding William Kearney.

David L. Turner, acting chief engineer of the First District Public Service Commission, New York City, has been appointed Chief Engineer.

Harry B. Oatley, Chief Engineer of the Locomotive Superheater Co., has been called to active duty as a lieutenant in the naval reserves of New York state.

Ralph N. Bergien, heretofore Chief Engineer of the Baltimore & Ohio R. R., has been promoted to General Manager of the Eastern lines, with offices at Baltimore, Md.

W. H. Vance, heretofore Chief Engineer of the Louisiana & Arkansas R. R., has been appointed engineer maintenance of way of the St. Louis Southwestern Ry., with office at Tyler, Tex.

Oscar F. Dalstrom has been appointed bridge engineer of the Chicago & Northwestern Ry. with offices at Chicago. Mr. Dalstrom for the past 7 years has been chief draftsman of the railway.

Leon P. Alford, for the past 10 years editor of the American Machinist, has become associated with Industrial Management, formerly Engineering Magazine, as editor-in-chief. John H. Van Deventer succeeds him as editor of the American Machinist.

J. E. Johnson, heretofore division engineer of the Pere Marquette R. R., has been appointed division engineer of the Michigan Central R. R., with offices at St. Thomas, Ont., succeeding S. D. Williams, Jr., who has been assigned to special work at Detroit, Mich.

Professor C. R. Richards, Professor of Mechanical Engineering and head of the department since 1911, has been appointed Dean of the College of Engineering and Director of the Engineering Experiment Station of the University of Illinois to succeed Dr. W. F. M. Goss, who has resigned to become President of the Railway Car Manufacturer's Association of New York. Dean Richards is a graduate of Purdue University, 1890, and has been successively instructor in Mechanical Engineering, Colorado Agricultural College, and Professor of Practical Mechanics, Professor of Mechanical Engineering, and Dean of the College of Engineering, University of Nebraska. Since entering the University of Illinois he served for two years as acting Dean of the College of Engineering during an absence of Dean Goss. Dean Richards is a member of the American Society of Mechanical Engineers, Western Society of Engineers, Society for the Promotion of Engineering Education, Sigma XI, Tau Beta Pi, Sigma Chi, and Sigma Tau.

INDUSTRIAL NOTES.

John G. Schmidt, formerly City Engineer of Norwood, O., has been engaged as sales manager for Warren Bros. Co., with headquarters in the Otis Bldg., Chicago.

The Institute of Paving Brick Manufacturers will hold its convention May 8-9 at St. Louis, Mo. H. H. Macdonald, 830 B. of L. E. Bldg., Cleveland, O., is Secretary.

The Marquette Electric Engineering Co., Inc., engineers and manufacturers, Chicago, Ill., announces the opening on March 1 of a new switchboard department, under the management of Paul Augustirius, vice-president.

The Granite Paving Block Manufacturers' Association of the U. S., at its meeting Feb. 27, elected the following directors: C. Harry Rogers, 31 State St., Boston; William Booth, 208 Broadway, New York; H. S. Lanpher, 90 West St., New York; Jos. Leopold, 233 Broadway, New York; Thos. Lahey, 31 State St., Boston; D. L. McLaren, Westerly, R. I.; H. E. Fletcher, West Chelmsford, Mass.; James Adamson, 208 Broadway, New York; F. T. Mason, Atlanta, Ga.; P. A. Wallenborn, Salisbury, N. C.; Thos. Woodruffs, Mt. Airy, N. C.

At a recent meeting of the stockholders of the Harrison Brothers & Co., Inc., of Philadelphia, the stockholders agreed to accept the offer made by the Du Pont Company of Wilmington, Del., and the paint firm became one of the Du Pont's subsidiaries. The sale marks the union of two of the oldest and best known manufacturing firms in the country. The Harrisons date from 1795 and the Du Ponts from 1802. The transfer to new owners will bring no radical change in the conduct of the paint business. This will be continued by the new owners and the products hitherto turned out by the Harrisons will continue to be made by virtually the same organization.

Road and Street Issue
of
Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

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Contract News Appears in All Issues

Volume XLVII. CHICAGO, ILL., MAY 2, 1917. Number 18.

"WASTEFUL SAVING" AND THE ADVICE OF HOWARD E. COFFIN.

Under some such title as "Wasteful Saving" many an editorial has recently appeared in the daily papers commending the admonition of Howard E. Coffin against curtailing expenditures for public works and manufacturing during the war. Mr. Coffin, who is an important member of the advisory commission of the Council of National Defence and an engineer, said:

> State activities, road building, public works, private industries, all must go on as before. Business must be increased, labor employed and the country kept going strongly ahead as a successful economic machine. We must have successful industries if successful tax levies are to be raised.

This is a statesman's view of the situation and one that deserves the wide publicity that it has received. Mr. Coffin urges municipalities, counties and states to continue with public work on as large a scale as ever, even though prices are above normal. He argues that the curtailment of expenditures now would result in a general disorganization of industry at the very time when prosperity is demanded. If there are to be heavy taxes, there must be income with which to meet them, and the income of no class of men can be reduced without reaction upon the income of other classes.

He says:

> Many firms are hesitating to close ordinary business contracts because of a desire to hold capacity open to meet possibly early government need.
>
> This spirit and this willingness to meet sacrifice and even financial loss in the government service is a most encouraging tribute to American patriotism. But we must remember that in the great struggle in which we have now become a part there is much to consider besides munitions, troops and battleships.
>
> In this country of vast resources we already have a tremendous equipment for munitions making, built up on foreign orders, and now immediately available through expiration of these orders. Except in limited cases there is little need for the development of new sources of supply. The dictates of common business sense require the utilization, as far as possible, of existing machinery.
>
> It seems to me, therefore, that a plain statement of general policy is most desirable.
>
> Upon the industrial side of the war three great problems, or perhaps I should say tasks, confront us:
>
> First and foremost, we must facilitate the flow of raw materials and finished products to our allies, and must provide the means of rail and water transportation therefor.
>
> Second, we must meet our own great military and naval building schedules.
>
> Third, we must plan to do all this with the least possible disarrangement to our own vast commercial and industrial machines.

Note particularly this last stipulation: "We must do all this with the least possible disarrangement to our own vast commercial and industrial machines."

Mr. Coffin is the first prominent man to voice publicly a sentiment that many business men have expressed in private conversations. A smaller engineer than he would have advised the public to reduce all expenditure for public works on the ground that prices are high. Indeed we have seen a few recent engineering reports to municipalities in which curtailment of improvements was recommended. Narrow indeed is the vision of civil engineers who offer such advice. They are of the tribe of wasteful savers. Carried to its logical extreme their argument would result in the cessation of all work, for all things are now high priced. They would bid the country starve because food is exceedingly expensive.

The statesman's plan is quite different. He calls upon all men to continue work, but with increased effort of mind and muscle, striving to create more produce and service with which to meet the demands of war. He calls upon men not to hesitate and waver as to business policy, but to move boldly forward. He speaks with a voice of courage, not with a whisper of timidity. Such a statesman is Howard E. Coffin, the engineer.

A ROAD BUILDING ERA IN CHINA AND RUSSIA, AND WHAT IT MEANS TO AMERICA.

The two newest republics, China and Russia, are among the most deficient in good roads. It has often been said of China that if her people once awaken to the economic possibilities of roads and railways, an astounding industrial transformation will take place. And the same holds true of Russia.

The war has fully awakened Russia. What it is that has also awakened China we do not know, but there is a bill pending in the Chinese Parliament for the establishment of a vast system of roads. The Chinese road, as it now exists, is nothing but a path for wheelbarrows and two-wheel carts propelled by men. Small wonder that Chinese labor, taken as a whole, is so slightly productive that 15 ct. is a big daily wage. Yet the Chinaman, as the editor can testify from personal experience, is an excellent worker, and he can be taught to use any kind of machinery.

In machinery for road building America easily leads the world. Starting with the invention of the rock crusher by Blake in the 50's (he was for 7 years engaged in devising the first crusher), American inventors have created scores of machines that are today used in road building. Almost all the grading machines are American, and even the old percussion rock drill is an American product. If Nobel, the inventor of dynamite, had been born in this country, we could have claimed almost a clean sweep of the leading road building instruments and devices.

But what bearing has this history upon roads yet to be built in China and Russia? This: As the nation that leads all others in the production of road building machinery we should lose no time in preparing to finance road building in those two great republics. By so doing we shall be able to place vast numbers of American machines in those countries, greatly to our own direct advantage, but even more greatly to the advantage of those nations.

Consider the vast numbers of machines that will be used on road work in Russia and China—those new-old countries. We shall send to them scores of thousands of dump-wagons, wheeled-scrapers, elevating graders, road machines, rock drills, air compressors, steam boilers and engines, pumps, concrete mixers, steam and gasoline rollers, scarifiers, harrows, plows, tractors, crushers, screens, asphalt plants, corrugated culverts, grab buckets, steam shovels, drag-line scrapers, auto-cranes, auto-trucks, industrial cars and locomotives, surveying and drafting instruments, etc., etc.—all these merely to build roads, and exclusive of what will be needed to build highway bridges.

Shall we also send American engineers and contractors to educate them in the use of our machines? This seems both probable and desirable. It used to be the custom to attribute all road building knowledge to France and England, and it is still true that in those countries excellent roads are built. But when it comes to low cost of road building, America can teach England and France a vast deal. We know how to build as good roads as they, and we build them at less cost even while paying twice as high wages. We are speaking now of the entire cost of a road, including its grading and culverts as well as the hard surfacing.

We are about to lend $3,000,000,000 to our allies in war. Would that there were no war and that we were lending that vast sum to finance road building in Russia and China! Perhaps this war-taken step in financing the needs of foreign nations may teach us to lend equally vast sums with which to buy American machinery for the works of peace—for roads and railways, for mills and shops, for mines and fields, for all the boundless uses to which men may put the endless products of American factories.

THE FIRST COUNTY MANAGER HAS ARRIVED.

In our issue of April 18 we published the resolutions adopted by the County Commissioners of Tillman County, Oklahoma, under which the county engineer, Pearl A. Little, was "appointed to take charge of the office of county manager." Thus the first county manager had arrived even while we were editorially asking "Who will be the first county manager?"

It is of special interest to note that this change was accomplished under the existing form of county government. By the simple process of delegating certain of their own duties to the county engineer, the county commissioners themselves created a county manager. This suggests the possibility of persuading other county commissioners to take the same sensible step. The resolutions of the Tillman County Commissioners summarize their reasons for this noteworthy step. They say that the road and bridge work of the county has grown to such proportions that it requires more managerial attention than the commissioners can give to it at their monthly meetings, also that it needs not only the constant supervision of some man, but that the man should have both "technical and practical education." They assert that such a man should, in addition, be able to keep a set of accounts. Note the significance of this last statement, you engineers who are ambitious to become managers. Note it and busy yourselves in the study of bookkeeping and cost keeping—two different things—if you are not already proficient in both.

We congratulate Mr. Little over his appointment as the first county manager in America, and we congratulate the commissioners of Tillman County for their far-sighted wisdom in taking this novel step. We renew our prediction that it will be only a few years until most of the 2,700 counties of America will have some form of county management in which one technically trained man of executive ability will give his entire time to the construction and maintenance work of the county.

With the first step now taken, in such a simple manner, civil engineers throughout the country should be encouraged to start movements leading to similar steps in other counties.

WHY NOT COMMANDEER CITY HORSES FOR FARMING?

This is the day of war-measure expedients and the inventive mind is unusually active. A reformed criminal suggests the placing of half a million convicts at work on the farms. A dealer in automobiles recommends the commandeering of all pleasure vehicles for the transportation of farm produce to city markets. Certainly it is not fantastic to suggest the use of such motor cars for delivery of goods in cities in place of horses. Then, going a step farther, transfer the horses to the farms where they would be far more useful.

America has shipped to Europe several hundred thousand horses and mules since the war began, and it has been said that many small farmers, particularly in southern states, are short of live stock needed on the plows and harrows. The editor, in a recent southern trip, saw more single mules than spans of mules at work plowing. It has always been a fact that the small southern farmer has had too few mules, and now this condition is even worse than it was before the world war.

In this connection it may be well to contrast practice in the far west with that in the east and south. In California, for example, one rarely sees fewer than a "four-up team" of mules on a plow, and usually the number is six mules to a plow. The plow is a gang plow that cuts three or more furrows, and one man controls both the mules and the plow. In this way, although wages are twice as high in California as in Alabama, for example, plowing costs considerably less per acre in California than in Alabama.

When one considers the simplicity of gang plowing with six mules, and the fact that one man thus does the work of three men driving separate teams, is it not astonishing that the California method of plowing is not used almost universally? The editor has put this question to many easterners, and the almost invariable excuse has been that the small size of eastern farms does not make it economic for a farmer to own six head of mules or horses. Quite so, but there are innumerable small farms in California where no mules at all are owned by the farmer, yet where all plowing is done with rented mules in six-up teams. In other cases the plowing is done by contract, the contractor moving from farm to farm.

Secretary of State Lane has made the suggestion that several hundred thousand acres of reclaimed land in the west be farmed by large gangs of men who can be shifted from ranch to ranch. Thus the work would be done on a large and economic scale. Excellent as this plan is, we believe that our suggested use of city horses on farms, coupled with the introduction of western methods of gang-plowing, would have a vastly greater effect than any other single plan yet suggested. The horses could be rented to farmers at $25 to $40 a month per span, and their owners would thus receive a compensation that would be a good income on the investment. The railways would be relieved of the burden of transporting more than a ton of feed per team per month.

We need more men on the farms, but we certainly need more draft animals also, if we are to increase the output of grain proportionately. We need also more intelligent use of the draft animals. Let this be the summer in which every farmer in every state in America shall be taught the economy of the California methods of gang-plowing and wagon train hauling with "six-up teams" driven by a "jerk line." We venture to say that not one farmer in ten knows what a "jerk line" is, and not one in a hundred knows how to harness and drive a "six-up team" with a "jerk line." Is this not a golden opportunity for the Department of Agriculture and the farm papers to teach the efficiency of an invention made more than half a century ago by some "prairie schooner" freighter? No patent specifies the "jerk line" method of driving 6 to 20-mule teams. No book on farming describes it. Yet many an inventor has won a fortune and celebrity through an invention of a far less economic merit than the simple "jerk line."

What is a "jerk line," anway? We quote from an article by W. A. Gillette, printed in Engineering and Contracting, April 14, 1909, and reprinted in Gillette's "Handbook of Cost Data," p. 1818:

> I have been especially impressed with the difference between the extreme West and East in handling teams. When I did construction work in the East, I did as Easterners do, namely, submitted to the dictation of teamsters in the determination of each driver to drive his own team and two extra drivers on a road grader drawn by three teams. Consequently, when we wanted to use three or four teams on a road grader or plow, three or four teamsters walked along, not driving but "herding" the teams. Once in a while we could find a man who could drive four horses, but not often; and, when he knew how, he wouldn't do it.
>
> Consider what it means to a contractor to have three extra drivers on a plow, drawn by four teams. It is just as ridiculous as

having two men loading wheel scrapers. Five extra men on an outfit as mentioned above means $7.50 a day, drivers' wages being $1.50 a day.

In the West we use one driver for one, two, three, four, five or more teams, and these drivers will handle three, four or more teams with one rein or jerk line with as much ease as the ordinary driver handles one team. It is a comparatively simple matter to train these teams to respond to a jerk line, and to the shout of "gee" or "haw."

For the benefit of those who do not know how to hitch a jerk line, I will explain. It is customary to use a strong braided clothes line. This line reaches from the "high" wheel animal to the "nigh" lead animal, and is fastened to the left hand side of the bit; from this main line a short piece of the line passes under the jaw to the right side of the bit, making a "Y." Fastened to the hames on the right side of the "nigh" lead is a "jockey stick" (a short piece of wood or iron) which reaches to a curb strap fastened to the bit of the "off" lead animal. A straight pull on the jerk line pulls the "jerk" line or "nigh" animal to the left, or "haw" and the "jockey stick" guides the "off" animal. A succession of jerks on the line causes the "nigh" or left lead animal instinctively to throw its head to the right, to escape from the jerking, and the "jockey stick" guides the "off" animal to the right also, or "gee."

A little patience will teach the lead team to "gee" or "haw" if the guiding words "gee" or "haw" are shouted every time the line is used. By fastening the following teams to the double trees of the team ahead, they will soon learn to follow the team ahead without being tied, and, as a matter of fact, it is not as handy in turning around if each team is fastened, as it does not permit them to cross over and out of the way of the chain while turning.

When a team has been properly trained in turning to the right or "gee" for example, the teams following the lead teams will step over on the left of the draft chain and follow it around until the chain is straight for the return trip; then each animal will cross over to his place on the right side of the chain.

In all of our team work we use but one driver, no matter how many teams are hitched to the load. In the hauling of gravel, sand or broken stone we use two or three wagons in a train. The trail wagons have a short trail tongue just long enough to permit the wheels to clear about three or four feet. The economy of this method of teaming is apparent when one driver is used to handle three wagons with three teams, for the wages of two teamsters are saved.

PROSPECTING FOR GRAVEL.

Frank T. Sheets, assistant engineer of the Illinois Highway Department, makes a suggestion that highway engineers may profitably heed. The engineer himself is usually too busy to search for gravel and sand beds, but he can encourage amateur geologists and school children to hunt for deposits of materials suitable for road building.

Pride in performing a public service is often sufficient to induce many people to keep an eye open for surface indications of the existence of road building material. But should not the highway engineer seek also to secure a small appropriation with which to reward those whose discoveries make available unknown resources of this kind?

The geological departments of some states have assisted in locating suitable ledges of rock and beds of gravel. Is it not desirable to enlist the active and continuous aid of such departments? Should highway engineers not make it a practice to go before state legislatures, urging appropriations of money with which to prospect for road building materials?

CITY HORSES THAT HAVE MORE SERVANTS THAN CITY MEN.

In our last Road and Street Monthly issue we gave the detail cost of maintaining horses in 1916 by the Division of Garbage and Refuse Collection of the city of Columbus, O. There were 17 men, including a night watchman, engaged to feed and care for 142 horses, or about 8 horses per man! The cost of this stable labor was nearly 29 cts. per horse per day.

A road or railroad contractor who spends as much as 5 ct. per animal per day for stable service is a rare bird. Usually his stable service cost is conspicuous by its entire absence, for the teamsters are required to feed and attend to the stock. But, making full allowance for the difference that exists in a city department, it needs no special acquaintance with stable etiquette to appreciate that even the most highly bred and sensitive equine guest could probably be persuaded to share the attention of one flunkey with more than seven other guests.

Because horses can give no tips to their waiters, it may, of course, be necessary to pay each stable attendant fully $100 a month. We do not criticise the municipal management on that score, particularly as we know how many years of painful study are required to qualify a man to serve hay and oats to a horse. But it does seem a wee bit like catering to the whims of these petted animals to yield to their demands that each of them shall have the eighth part of a hostler's time. Can't some way be devised to placate these 142 petulant creatures? If not, why might it not profit the city of Columbus to ship them in body, with their 17 attendants, to the farms of Ohio that badly need the animals and can put up with their retinue, cortege, or suite for the sake of the society of these equine princes?

Tennyson's appropriate lines from the "Princess" come to mind:

> To horse we got, and so
> Went forth in long retinue following up
> The river as it narrowed to the hills.

180 COUNTIES TO SPEND $19,000,000 ON ROADS THIS YEAR.

In our Road and Street Monthly issue for April we gave in detail the funds available for county road work in 180 counties. In 12 States 180 county engineers reported to us the amounts that will be spent for road work this year. Summarized the data are as follows:

Ohio, 7 counties	$ 1,574,000
Indiana, 3 counties	330,000
Illinois, 29 counties	3,866,000
Michigan, 13 counties	2,716,000
Wisconsin, 28 counties	2,212,000
Minnesota, 31 counties	1,627,000
Iowa, 33 counties	1,439,000
Missouri, 4 counties	870 000
Oklahoma, 9 counties	272,000
Kansas, 8 counties	188,000
Oregon, 4 counties	1,108,000
Washington, 11 counties	2,777,000
Total, 180 counties	$18,979,000

This is an average of slightly more than $100,000 per county. If this average should be maintained for the 1,700 counties that have county engineers, a total of $170,000,000 would be spent for road work in 1917 under the direction of county engineers, to say nothing of road work done under the direction of other engineers in the remaining 1,000 counties, and of work done under the direction of State engineers.

The total revenue applied to roads and bridges in 1904 was about $80,000,000 and in 1914 it was over $240,000,000. That the expenditure for 1917 will exceed $300,000,000 is a foregone conclusion. Great as this sum is, it is inadequate. Of our two and a half million miles of roads not 12 per cent are surfaced with anything but the original dirt. We could be profitably investing a billion dollars every year in roads. Even that would be less than $10 per capita.

EDITORIAL COMMENT.

There are 2,500 miles of gravel roads in Michigan, or 60 per cent of the total improved road mileage. The average cost of 68 miles of 9-ft. gravel roads, 8 in. thick after rolling, was $2,500 per mile. This includes rolling and harrowing. Such a road carries 200 to 500 vehicles per day with an annual maintenance cost of $100 to $200. Frank F. Rogers, State Highway Commissioner, says that for light traffic a well built gravel road is truly economical where the construction cost does not much exceed $2,500 a mile. He emphasizes the importance of not having more than 10 per cent of clay in the mass as a binder.

In comparing maintenance costs of different types of pavements no very broad conclusions are possible unless the average age of each type is given. This seems an almost self-evident generalization, yet we repeatedly come upon maintenance cost comparisons in which not a word is said as to the age of the pavements. Asphalt, as is well known, usually shows very low maintenance costs for 10 or 12 years, when they may suddenly rise. The same general phenomenon is true of almost every type of pavement, not excepting concrete.

METHODS OF HANDLING EARTH IN ROAD CONSTRUCTION.

Contributed by Chas. R. Thomas, Assistant Engineer, Construction Service Co., New York.

Light Excavation and Embankment on Previously Graded Old Roads.

Light excavations and embankment on a previously graded old road is generally taken to mean such work as the smoothing out of slight hills and depressions that mar the profile of the road, widening and sloping cuts, building earth shoulders, cleaning and smoothing the road surface and improving the old cross-section (generally necessary between the pavement and the ditch bottoms) and other grading work of a similar nature. Earth handling of this type is generally encountered on roads that have previously been improved in the vicinity of towns, and are to be further improved by the construction of some new type of pavement, such as brick, concrete or bituminous macadam. There will seldom exist on a long section of such work more than one or two cuts or fills exceeding 2 ft. in depth, but frequently these works involve a large amount of excavation, such as required in the reduction of a long grade on a hill or the filling of the approaches to a bridge.

The quantity of earth to be moved on previously graded old roads is comparatively small. In New York State, where most of the roads have already been graded to some extent, it has been found that the average amount of excavation per mile seldom exceeds 5,000 cu. yd. While this small yardage of earth is an advantage, the cost of such excavation is generally quite high, averaging from 30 to 50 ct. in New York. The same high cost of earth handling is to be noted in a number of other Eastern states, but as a rule the high costs occurred in regrading old roads already in fair condition with respect to grades.

The waste and shrinkage of earth on work of this type is quite heavy. Fills are generally very thin and must be made of selected material. The widening of fills always involves a waste of earth, and since surface soils are never so compact as subsoils, the shrinkage is greater. As a general rule, a minimum allowance for shrinkage and wastage of from 25 to 33⅓ per cent excess excavation over embankments should be made, and these figures increased for special cases.

Since it is generally desirable that the earth that is to serve as a foundation for the road be disturbed at little as possible, earth for shoulders should be borrowed and the undisturbed old roadbed in the center of the road used as the subgrade. It may frequently be advisable to haul earth a considerable distance or to waste it in order to save filling over an old roadbed that may be used as a foundation for the new pavement.

The organization used for light grading work of the type outlined will vary considerably with the size of the project and local conditions of labor, as well as the type of earth encountered and the length of haul necessary to place it properly. Since quite frequently as much as 33⅓ per cent of the total excavation consists of constructing suitable shoulders or the making of very thin (pancake) fills, and the haul for material used for this purpose often exceeds 1,000 ft., it is readily seen that a large amount of earth must be handled in wagons, although drag scrapers may be conveniently used in some cases. Occasional use for a wheeled scraper gang may be found, but as a rule little of the work can be handled economically with wheeled scrapers.

For the purpose of illustrating a typical organization, suppose it is desired to pave a section of road three miles long in rolling country, the excavation averaging about 5,000 cu. yd. a mile. Under these conditions, the grading work may consist of removing a half dozen bumps in the profile of the road, the reduction of the grade on a long hill, the building of shoulders for the pavement, the widening of a few fills and the excavation for drainage structures.

A gang of about 6 drag scrapers would be used to remove the bumps, the earth excavated being wasted, or loaded into wagons and hauled to other points on the road to form shoulders or for use in their filling in case the old road were surfaced with gravel or stone. The wearing surface of an old road may, as a rule, be considered as select material. On the long hill it is probable that an old cut must be widened and hand picking and wagons must be employed to remove this material economically. In a majority of cases wagons would be used to remove the remainder of the earth. In widening the old fills a wagon runway would be started at the foot of the fill sufficiently wide to accommodate a wagon, and the additional width made by the gradual filling of this runway. A large part of the work would be accomplished at times when teams were not busy at other hauling. The foregoing is merely one method of accomplishing the work; others might be more satisfactory under different conditions. But road work should be so planned that teams will be kept busy at all times.

In earth handling of this type there is some danger of providing too many shovelers to the wagon. Frequently 5 men and the driver, working continuously at the wagon, is about the right number. This gang will load a 1½ cu. yd. wagon in about 8 minutes. It is always necessary to have an experienced man with a good eye for leveling earth working at the dumping point. The total number of shovelers, spreaders and wagons used will depend largely on the length of haul. As a rough rule, a unit wagon outfit with 5 men loading and one dumping on a 500-ft. haul would consist of three 1½ cu. yd. wagons and each wagon would average about 4 trips an hour. Another wagon should be added for each additional 500 ft. of haul. Multiples of this outfit would call for 10, 15 and 20 shovelers, respectively, but not so many men at the dumping point.

Thorough plowing for hand shoveling and wagon work is the secret of economical shoveling. Unless the earth is thoroughly pulverized by the plow, the efficiency of the shovelers is materially reduced. It is not sufficient merely to turn the earth, it must be plowed fine, the plowman taking a thin furrow slice and making many trips. Plowing should be sufficiently deep for the shoveler to stick his shovel straight down, even if a second plowing is necessary. In hard, dry earth the writer had used a rooter plow to advantage in preparing the earth for shovelers. In plowing a cut it is usually desirable to plow only a half width at one plowing.

Drag scraper work should be so organized that teams can work in a circle, the driver always walking inside the circle. On a haul of 100 ft. one scraper holder will load about 3 teams and a good man on the dump will handle 6 teams. The scraper holder should be a man of good avoirdupois. So many conditions arise to vary drag scraper work that it is useless to set rules. Suffice to say that the nearer the work approaches what is known as "round and round" work, where the teams work in a circle with the drivers on the inside, the more rapidly will the earth be handled. There is a knack of steady pulling in loading that the horses soon learn, and the driver should always pull out of the loading runway as soon as loaded to avoid trampling the plowed earth. Rather small horses or active mules weighing about 1,100 lb. that step out lively are preferred by many for drag scraper work. A No. 2 scraper is useful for miscellaneous work, but if any considerable amount of earth is to be moved, a No. 1 will prove much more economical. Six and 10 trips to the cubic yard of earth moved is about the average performance for No. 1 and No. 2 scraper, respectively. A drag scraper working continuously will average from 2 to 3 cu. yd. per hour on a 100-ft. haul.

On pick and shovel work such as sloping banks, general trimming and loading earth into wagons, it is well to have several men work together. For sloping, mattocks are usually superior to picks. This work is most economically accomplished while grading is in progress, keeping the banks sloped as the cut is carried down. A man will ordinarily shovel into wagons about 8 cu. yd. of light clay, 12 cu. yd. of loamy earth and 15 cu. yd. of sandy soil in a 10-hr. day, provided the ground is well plowed.

The widening of old cuts, a problem frequently encountered on this class of work, is both expensive and slow. Much work can frequently be saved by careful designing in which the alignment is made so that the widening is all on one side of the cut. If the cut is widened as much as 6 ft. it is possible to dig runways and work scraper teams on the slice of earth to be removed. If the cut is not widened this much, a bench about 2 ft. wide may be picked out and a plow used to loosen the earth, men with mattocks raking it to the foot of the slope where the shovelers can handle it.

Some difficulty is generally experienced in breaking into an old gravel or macadam road. By starting at the edges with a rooter plow and breaking in gradually using either a traction engine or 6 good horses weighing around 1,800 lb. each, slow but sure progress will be made. Six horses will loosen about 100 lin. ft. of 12-ft. gravel road in a day.

Finally, on light grading of this type it should continually be borne in mind that wherever possible the old rock surface should be preserved intact, the fills avoided unless of excellent material, and the operations so arranged that grading and paving work will not interfere.

Excavation and Embankment on Roads Not Previously Graded.

Earth handling in the improvement of roads not previously graded approximates somewhat the methods applicable to railroad grading. As a rule, some grading is done on the entire length of road, not merely at certain points. In level sections of the country the work will consist largely of constructing ditches and making fills, in rolling sections a series of cuts and fills are generally made and in hilly sections heavy side hill excavation is frequently encountered. All types of earth-moving equipment and almost any organization that is effective may be used on work of this kind.

The quantities of earth to handle per mile of road graded will vary, of course, with the topography of the country and the degree of improvement contemplated. In level sections, where the digging of ditches constitutes the larger part of the grading, it will frequently be necessary to move from 3,000 to 8,000 cu. yd. of earth per mile. Such excavation is frequently "round and round" drag scraper or scraping grader with a maximum haul of 100 ft., and may generally be accomplished at a cost of from 15 to 20 ct. a cubic yard.

Cutting and filling in rolling country where the average distance between crests of hills does not exceed about 800 ft. will probably be accomplished most economically with wheeled scrapers. The quantity of earth moved will often vary from 6,000 to 12,000 cu. yd. per mile, depending largely of course upon grades. The cost of such excavations will vary from 20 to 30 ct. per cu. yard.

The reduction of the grade on long hills is frequently encountered in slightly rolling sections. This work is quite expensive, frequently requiring the use of a steam shovel and wagons or an industrial railway. Grading of this type is much more costly than cutting and filling in rolling country. Wagon work of the type will cost from 20 to 50 ct. a cubic yard, depending on the length of the haul.

The redeeming feature of earth excavation in hilly sections is the fact that while quantities are large, seldom is the haul very long. As a rule, excavations will seldom fall below 8,000 cu. yd. per mile and will frequently exceed 20,000 cu. yd. for short distances.

Digressing somewhat from the subject in hand, the writer desires to protest against the general practice of two features of road design of special application only that have unfortunately been adopted as fundamental principles by some engineers. These errors of design are the general adoption of which is known as a "rolling profile" and the avoidance of grades exceeding a certain maximum by the laying out of a tortuous development of the alignment to secure additional length. The chief objections to "roller coaster" grades, as they are sometimes called, is the poor drainage obtained in the valleys and trouble experienced in maintaining these valleys. Also the number of small culverts required is greater on a road having a rolling profile than where long grades are used. A straight alignment is vastly more important at the present time than it was a few years ago. If this straight alignment is sacrificed to short and dangerous turns to overcome a grade slightly in excess of the maximum adopted, maximum grades bearing no very great economic relations to economy of operations as in the case of railroads, much of the advantage gained by straight alignment is lost. If the grade on a hill is excessive it should be left until it can be reduced by cutting and filling. While there is truth in the saying that "the road around the hill is no longer than the one over it," the saying has been quoted somewhat too frequently.

In the excavation of ditches on roads in level sections, where drainage is of primary importance, it is generally held that the road should always be placed on a fill. The ditches are therefore borrow pits and canals serving to furnish earth for the fill and to drain the surrounding country as well as the road. Work of this type is probably best accomplished with drag scrapers and scraping graders. An elevating grader might be employed on such work, but since the ditches must be completed with other tools, it is not much used. The elevating grader is frequently a "white elephant" when used on road construction. Where ditches do not exceed 3 ft. in depth a scraping grader, assisted by a small gang of drag scrapers, may be used for the entire work.

The following method of procedure was adopted by the writer on a construction project of the foregoing type: Grade stakes were set at 100-ft. intervals on both sides of the road about 10-ft. beyond the ditch line with the cut from the top of the stake to the ditch bottom marked on the face. Gradually diverging outside line furrows to allow for the gradual deepening of the ditches were plowed through, using great care to have them straight. Two Road King graders were used on this work because of their marked ability to hug the slope of a ditch. The graders were pulled by 8 mules weighing about 1,200 lbs. each. Plowing for the grades was commenced at a point about one-fourth the distance from the haunch to the ditch bottom (the road had previously been slightly rounded), using two 4-mule plow teams. One grader followed the plows digging out on furrow and the other grader carried toward the center. When a sufficient amount of earth had accumulated at the quarter point of the road both graders carried to the center. In work of this type it is well to handle the loose earth in ridges, this leaving a hard bottom for the teams and grader wheels. Grader runs about a mile in length were used until the minimum depth of ditch was obtained. Runs were then stopped at about 1,000 ft. intervals from the upper part of ditch and the ditches carried deeper. Grades were tested occasionally by means of a straight edge, level and short rod. Where the ditch depths exceeded 3-ft. it was found economical to rough out the ditch with drag scrapers and use the grader only for smoothing. Where earth must be moved laterally over 15 ft. the use of drag scrapers is generally more economical than the scraping grader. The cost of excavation on this job averaged about 12 ct. a cubic yard with teams at $4 a 10-hour day. A bottom width of at least 18 in. is necessary in ditches constructed with drag scrapers. It was also found advantageous to use drag scrapers for moving to the center the earth on the slope beyond the center line of the ditch. The drag scraper gang consisted of about 6 teams using No. 2 Western scrapers.

Quite frequently the soil encountered in road grading in level sections of the country is of a nature that becomes very hard upon drying out, and it is quite important to keep the earth leveled during construction. One of the secrets of even scraping grader work is maintaining a smooth track for the wheels of the grader. Also in hitching to the grader teams should be worked abreast as much as possible.

The use of traction engines and one or more trailing graders has come into vogue within the last few years. The great advantage derived from this arrangement is the reduction in the expense of plowing, and the use of this equipment is advised for general earth road repair and for road construction where it is unnecessary to pay great attention to ditch grades. The heavier the grader used in engine grading, the more successful will be its operation and the more economically will the work be accomplished.

A newly constructed earth road will settle in bumps and ridges in spite of all the care that may be taken in its construction. An occasional trip with the scraping grader over recently completed work will alleviate this trouble. Frequently it is necessary to use drag scrapers to fill depressions that may develop. A drag may be used for this work on loamy soils.

In sections where the topography is rolling and short cuts and fills are necessary, the wheeled scraper may be used to advantage. The efficiency of a grading crew and the skill of the road foreman is judged by the experienced dirt mover from the operation of a wheeled scraper gang. The grading of the railroads of the United States was accomplished with wheeled scrapers, and a high degree of efficiency has been obtained with these implements on such work.

The economical handling of earth with wheeled scrapers is based upon the strict observance of a multitude of small matters. It has been the writer's experience, however, that high costs result mainly from the lack of a proper regard for the following points: (1) Poor plowing of the earth and consequent small loads; (2) the number of wheelers in use not properly proportioned to the length of haul and consequent idleness on the part of the snatch team or standing of wheelers waiting to be loaded; and (3) a poorly trained snatch team and consequent unfilled wheelers. It is needless to state that the movement of earth varies directly with the continuity of operation of the vehicle transporting the earth. Rapid operation is not so essential as continuous operation. This law applies to the output of all machines, although it is especially well illustrated in the operation of a wheeled scraper gang.

The length of haul economical for wheeler work usually varies from 100 to 800 ft., and occasionally a 1,000 ft. haul is economical. It is seldom economical to operate less than 4 wheelers in a gang, and a snatch team should always be provided. If 4 wheelers are kept busy on a 100-ft. haul another scraper should be added, as a general rule, for each 150 ft. of longer haul, although this will depend somewhat upon the condition of the dirt and the freedom of loading. For all ordinary work it is desirable to use a No. 3 wheeler and horses or mules weighing not less than 1,200 lbs. No. 2 wheelers are somewhat easier to handle, but the larger size is the more economical tool under ordinary conditions where a wheeler is used to advantage. The average wheeler load will vary from ¼ to ½ cu. yd., averaging about ⅓ cu. yd.

Deep and thorough plowing is necessary if full loads are to be secured. Plow half the cut and make runways at least 150 ft. long if possible. Double plowing is frequently desirable. Loading is easier if backfurrows are plowed to fit the tread of the wheelers. Look after the necks of the teams—use well-fitting, all-leather collars and, as a rule, no pads. If an animal's neck becomes sore, use a larger collar with a pad and cut out the pad over the sore spot. Doctor the sore immediately. Keep the wheeler pole well elevated; a swaying pole is a prolific cause of sore-necked animals. If the ground is stony and full loads difficult to secure, have a man with a shovel finish loading the wheeler. Dump wheelers down hill. If a scraper breaks down, have the team pull out of the runway. In loading, start steadily, and if the teams stop break the wheels out—do not try to start a partially loaded wheeler—take it out on the man, not the team. Use a heavy man loading, and one that knows his business. Keep the harness in good condition and provide long lines. Keep an old wheeler in good repair or scrap it—otherwise it will be a losing proposition. Select the wheeler teams from animals that walk at about the same rate of speed. Use an active and intelligent team on the snatch. The list might be continued, for every wheeler foreman has his own rules. Economical wheeler work is dependent upon small matters such as these.

Costs vary widely, but the following will apply under many conditions where the price of teams does not exceed 45 ct. an hour: Plowing will cost from 1 to 1½ ct. a cu. yd. The cost of loading, dumping and idle time will vary from 6 to 8 ct., and transportation will cost from 4 to 5 ct. for each 100 ft. of haul. On this basis, the cost of handling earth on a haul of 500 ft. varies from 25 to 30 ct., which is about right.

The hauling of earth in very hilly or mountainous sections involves the use of practically all types of earth-handling machinery and organizations for such work. Much side hill excavation is frequently encountered, and cuts and fills are often quite deep. Materials that slide readily on slopes are frequently encountered, and various accessory structures are used to hold the grade to the desired shape.

Light Grading in the Repair of Old Roads.

Earth handling in the repair of old roads consists generally of ditch cleaning, using drag scrapers and a scraping grader; the smoothing of shoulders that have become rutted by the wheels of vehicles or eroded by water running from the crown of the road, using a scraping grader; and filling depressions and washed embankments generally occurring at bridges and around the endwalls of culverts, using wagons.

The effective maintenance of earth roads generally requires that they shall be gone over once in the fall and once in the spring with a scraping grader. An organization used by the writer for such work was as follows:

Men and teams.	Cost per 10-hr. day.
1 foreman, who operated the grader	$3.00
2 drivers at $1.50	3.00
3 laborers at $1.50	4.50
1 cook and supply man at $1.50	1.50
Labor	$12.00
10 horses or mules at $1.50	15.00
Feed for 10 animals at 75 ct.	7.50
Rations for 7 men at 50 ct. a day	3.50
Fuel, repairs and incidentals	3.00
Teams and subsistence	$29.00
Daily cost of operation	$41.00

Equipment:
1 6-horse scraping grader.
2 No. 2 drag scrapers.
1 steel road drag.
1 tool box on wheels containing picks, shovels, mattocks, extra singletrees, carpenter tools, lanterns, spare parts, open links, sledges and such other small tools as may be required.
2 slat bottom wagons.
1 cook and feed tent.
2 sleeping tents and 7 cots.
1 small cook stove.
Water barrel, feed trough, buckets, lumber, etc.

This outfit, after establishing camp, would proceed to repair all earth roads within a radius of about 3 miles from the camp, and upon completion of this work would move to a new camp site about 6 miles distant.

As a rule, the outfit completed the repair of about one mile of road a day, cleaning out the ditches, filling in bad ruts and depressions that had developed and placing the road in condition to bear the season's traffic. Camp was generally moved every ten days or two weeks.

COST OF RESURFACING TRENCHES.

The Department of Street Maintenance and Inspection of the city of Los Angeles, Cal., has a permanent organization for handling the resurfacing of trenches. The organization consists of one general foreman and five sub-foremen. Each sub-foreman has a sufficient force of labor and teams or trucks to do the work required. This force is variable as the needs require. During the fiscal years 1915-1916 the bureau received and executed 25,388 work orders.

The areas resurfaced by these orders and the cost per unit measurement (not including overhead and administration), according to the last annual report of Homer Hamlin, City Engineer, were as follows:

	Sq. ft.	Per sq. ft.
Asphalt	124,268	$0.2656
Macadam	37,196	.1571
Brick	8,033	.4012
Oil gravel	549,473	.0885
Dirt	480,262	.0014
Sidewalk	16,105	.2587
Granite block	4,285	.2500

RECENT PRACTICE IN THE CONSTRUCTION OF GRANITE BLOCK PAVEMENT.

At the convention of the American Road Builders' Association at Boston during February, 1917, a paper was presented by Mr. William H. Connell, Chief Bureau of Highways of Philadelphia, Pa., describing the recent practice in granite block pavement construction.* In the discussion of this paper a number of interesting points were brought out. An abstract of the discussion, with comments, is embodied in a paper presented on April 12 by Mr. Connell before the 4th Canadian and International Good Roads Congress. Extracts from this paper follow:

In discussing the subject of granite block pavements at the American Road Builders' Association, the question was raised as to the advisability of eliminating the pea-stone in the grout filler on the ground that the blocks could not be held in position while ramming. In answer to this, attention was called to the fact that with the close joints in the newer types of dressed granite block pavements there would be little, if any difficulty in this respect. As a matter of fact, in cases where the pea-stone has been eliminated no trouble has been experienced. Of course with the old-style wide joint pavement it is easily seen that it would be necessary to have the pea-stone to hold the block in position while ramming.

The purpose of the elimination of the pea-stone in the joints was well expressed by Mr. C. D. Pollock, Consulting Engineer, New York, who stated:

> In regard to the disintegration of the grout at the joints, in an investigation of the Granite Paving Block Manufacturers' Association we found that the trouble came from the placing of pea-stone at the bottom of the joint, resulting in the underpinning of the block during ramming. Careless workmen get the pea-stone high in spots, and consequently obtain a good grout only in the top inch or inch and a half of the joint. Then with the advent of damp weather in summer the expansion would bring the load on that small area and crush the top off the blocks. We had cubes made from the bottom portion of the block which was intact, and tests made for crushing strength showed that the stone was normal. We found there was no material difference in the causing of these broken joints whether the granite was a comparatively sound granite or the hardest pavement block in the New York market. We made these examinations in Brooklyn and New York and Bloomfield and surrounding places. I think the whole of that trouble is caused by having the pea-stone at the bottom of the joints. If you eliminate that and get the grout clear down to the bottom of the joint you will find no failures.

Of course, it is perfectly obvious that in order to lay good pavements we must eliminate all possible conditions that are liable to result in failure. In doing this, we must also take into consideration the human element and provide for methods of construction that will, as far as possible, eliminate the personal equation entering into the construction; or, in other words, we should not depend any more than is absolutely necessary, in such an essential matter as this, on perfect workmanship. Mr. J. T. Rhoades, Superintendent of Streets of Worcester, Mass., states that they do most of their own work, and the same men have been performing this work for a number of years, and in this way they can secure good results by using the pea-stone, as they make it a point to have it only in the bottom of the joint. Where the work is done by contractors, it is better to eliminate the pea-stone entirely and avoid the possibility of failure that would occur from bringing the pea-stone too high up in the joints through poor or careless workmanship.

There was also considerable discussion as to the advisability of using a shallow block; that is, a block 3½ in. or 4 in. in depth. It seems that there is little ground for discussion in this respect, as it is intended that the shallow block shall only be used on light or medium traffic streets.

Some question was also raised relative to the tests for granite block. Some cities specify that the blocks should come from certain definite quarries, or from a quarry that will be acceptable to the engineer. There should be a more definite method in stipulating just what the requirements should be than to leave it up to the personal judgment of the engineer. After making an inspection trip of the different quarries and an investigation of stone laid by those quarries it has been determined to make the test for the Philadelphia specifications as follows:

> Compressive Strength.—The granite shall have a compressive strength of 16,500 lb. per square inch, except when unusually heavy traffic conditions are to be encountered, in which case the compressive strength shall be 20,000 lb. per square inch. It is understood, however, that a strength of only 16,500 lb. will be required unless definitely stated otherwise in the proposal. The toughness shall be not less than 11, as determined by the method employed by the United States Department of Agriculture.

However, it might be stated that these requirements are not entirely satisfactory. Very extensive studies and tests are being made in Philadelphia at the present time to determine upon new standard tests that will insure satisfactory results. Of course, it must be borne in mind that on streets such as West St. in New York, where you have an enormous amount of heavy steel-tired trucking, that it is desirable to use the hardest granite that can be secured, but, at the same time not be so hard that it will be brittle and chip, and on such a street it might be desirable to raise the crushing strength to at least 30,000 lb. However, the New Hampshire and Southern granites that test from 16,500 lb. upward, are entirely satisfactory for probably 95 per cent of streets where it is desirable to use a granite block pavement. The Worcester, Mass., pavements, which have been in service upwards of 15 years, and have had practically no money spent on them for repairs, are the softer granites and they have proven entirely satisfactory on heavy traffic streets.

Another very important point that was emphasized is not to leave any more grout than is absolutely necessary on the surface of the finished pavement. When there is an excess on the surface of the pavement and this grout chips off, it often takes with it a portion of the grout in the joints, and this will develop a weakness in the pavement. This is very important, as there was a time not many years ago when it was considered good practice in many localities to smear the grout over the surface of the pavement. Again we might point to the Worcester, Mass., experience, where the best granite block pavements have been laid, and where they have always made a practice of leaving practically no grout on the surface of the pavement.

Another very important feature was brought out in the statement of Mr. Rhoades to the effect that in Worcester they have recently been placing expansion joints parallel and adjacent to the curb, beginning at the bottom of the concrete base and going right up through to the top of the roadway pavement on streets having concrete curbs and sidewalks, which without expansion joints would make more or less of a continuous and rigid construction. The purpose of these joints is to eliminate the vibration felt in the abutting buildings caused by heavy loads traveling over the pavements.

Great stress was laid in the recent paper on the matter of inspection of the construction work and it was stated by Mr. Durham, former Chief Engineer of the Borough of Manhattan, New York City, who has had considerable experience in laying granite block pavements, that in his opinion it is more important with this type of pavement than with any other to have inspectors who appreciate the importance of apparently trivial details in connection with the inspection of the block and the performance of the construction work. These details appear unnecessary to the average contractor, and would to the average layman, but slight neglects in the performance of the work are the principal causes for failures in granite block pavement construction.

A very important matter in the construction of granite block pavements is the proper ramming of block. Where the specifications do not state the number of rammers that shall be employed to follow up the work of a definite number of pavers you will invariably find that the ramming of the block is neglected and that the contractor will employ just enough rammers to slightly ram each block. Of course, the pay for rammers is about $3.50 per day, and the fewer the contractor has to employ the cheaper the work can be performed, so that instead of stating that the blocks must be thoroughly rammed it is most important to state the relative number of pavers and rammers that shall be employed, as is stated in the following quotation from the Philadelphia specifications:

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*See March 7 issue of Engineering and Contracting for abstract of this paper.

> Number of Rammers to Be Operated.—On all granite block pavement construction the number of rammers to be operated shall be in the proportion of 1 rammer to every 2 pavers.

HOME-MADE STREET WAGONS.

The steam roller tender and tool wagon shown in the accompanying illustrations were built in the shops of the Department of Streets and Engineering of the city of Springfield, Mass. Running gear from discarded garbage wagons and other old materials were used. Several of these wagons were constructed. The tool wagons have five compartments for different tools, so arranged as to carry implements of different sizes. The steam roller tender has three compartments. The two under the front are utilized for roller picks, lanterns, oils, etc. The main body carries 2 tons of coal. One-half of the roof is hung on hinges which allows for filling, while a shutter arrangement in the rear allows for the removal of coal for the rollers. F. H. Clark is Superintendent of the Department.

Tool Wagon Built by Street Department, Springfield, Mass.

Steam Roller Tender.

State Aid Road Construction in Illinois.—During the period from July 1, 1914, when the State aid plan went into effect, to Jan. 1, 1917, 478 miles of State aid roads were placed under contract by the Illinois Highway Department. The mileage of the various types and the percentage completed on Jan. 1 last were as follows:

Type.	Length. Miles.	Per cent completed.
Brick	18.00	88
Concrete	[illegible]	64
Bituminous concrete	1.51	5
Bituminous macadam	12.00	82
Water-bound macadam	13.30	73
[illegible]	21.53	82
[illegible]	123.71	16
[illegible]	77.61	82
Bituminous macadam resurfacing	5.06	84
Total	478.16	

CONTRACTORS' PLANT AND EQUIPMENT FOR STATE ROAD CONSTRUCTION.

Some interesting observations on contractors' plant were given by Mr. John H. Gordon, a road contractor of Albany, N. Y., in a paper presented at the 14th annual convention of the American Road Builders' Association at Boston, Mass. In his paper, which is given in abstract below, Mr. Gordon discusses the plant that he has found most useful in his New York State road work.

The contractors' plant and equipment proper consists of the large and expensive tools which are carried on his books as an asset of his business. Conservative management should mark off yearly a material depreciation, but in the lean years this is sometimes omitted, and the contractor deludes himself into thinking that his resources are much greater than their actual market value even when favorably sold.

The steam roller in general use is the 10-ton double-cylinder roller, although there are some makes of single-cylinder rollers that are good. There are also some heavier rollers, 12 and 15-ton, which have their special use, but the 10-ton roller for all purposes has been found, after many years' experience, generally satisfactory and as heavy as is needed. Where there is sufficient work to warrant and the controller can afford the equipment, the 8-ton tandem roller for finishing bituminous roads is an excellent tool.

The double-cylinder roller is coming more and more into use for hauling, a purpose for which the single-cylinder roller is not so adaptable. Many contractors hesitate to use their rollers for hauling, and yet where conditions permit, where the road is not too hilly, water available, etc., it is one of the very cheapest methods of hauling. The life of a roller is indefinite; with care it will surely last 10 years and more. An oil pump for the cylinders will repay its cost many times over. A roller should be cleaned out often, at least every two weeks, and this is true of all steam boilers on the work. And the use of a compound suitable for the water of the locality is to be recommended. These details are frequently overlooked, but are valuable helps in continuing the efficiency of the tools and prolonging their life.

The use of steam shovels on State road work has been made possible in the past few years by the construction of a shovel of smaller size. Unquestionably there is a material saving in the initial cost of steam shovel excavation over any other method, but much consideration should be given to the purchase. A firm with ample capital and doing a large business will find it an excellent tool, but the smaller contractor building one or two roads a year should make haste slowly owing to the number of roads of light excavation. An idle tool depreciates almost as rapidly as a busy one, and the size of the investment makes the interest item and depreciation in market value factors of importance. There is also to be considered the greatly added wear and tear on the wagons used in loading from the shovel.

The stone crushers in general use are the jaw crushers, and the size favored is the one with the jaw opening of 10x20 in. or 12x20 in., which is the largest size that is portable. There are some jaw crushers in use of a considerably larger jaw opening. These are mounted on skids and are well adapted for use where a considerable quantity of stone is to be crushed at one location. The gyratory crusher as at present constructed is only suitable for a stationary plant.

The size of the boiler and engine to be used is important; a 30-35 H.P. is to be recommended, although many smaller are in use. The 50-ton portable bins may be used to advantage where the output is to be approximately 3,000 cu. yd. For a larger output the 100-ton stationary bin will more than repay the additional cost, by providing storage capacity and facilitating the progress of the work. The capacity of the 10x20 or 12x20-in. crushers is about 125 tons in 10 hours, but the difference in the operator will make a variation of as much as 20 per cent. The nature of the stone to be crushed is also a material factor. The number of revolutions the crusher fully runs should never be less than 280 to 290, as reducing this speed diminishes the output. The use of one jaw of manganese steel will prove a saving.

Much thought and care should be given to the selection of the site for the crusher and to its erection. The crusher itself should be set on concrete so as to reduce the vibration as much as possible. It should be placed as near the quarry or source of supply as is safe, and the approaches should be graded so as to make easy the hauling to the platform of the largest load. The constant lubrication of all parts of the crusher, screen, elevator, etc., is an absolute necessity. The bin for tailings should be placed on the end at right angles to the supply bins so as to have as little interference as possible with the teams or trucks in loading. These details are often overlooked and the additional cost where neglected may run into thousands of dollars even on one road.

In the matter of hauling stone, asphalt, etc., a well-known contractor once said that where this work could not be done economically with teams he preferred to let some other fellow build the road. And it is in part true that other methods of hauling have not reached entire efficiency. Most contractors are using one or more motor trucks, with or without trailers. On long hauls over improved roads their value is unquestioned, and for repair work and resurfacing they are economical. On new construction their value is debatable, and the sensitive mechanism over new grading, sub-base, etc., is too often put out of order. Where one truck only is possible the 3 or 3½-ton is usually more adaptable than the heavier, and can be used for more purposes. It should be equipped with hydraulic hoists.

The traction engine and train is not in as general use as it was some years ago, but under certain conditions is still desirable. Where the quarry or source of supply is a considerable distance from the road, and the connecting roads are unimproved, it is usually economical. The steam roller with train, with not too large a load, provides one of the best and cheapest forms of hauling, and unlike the traction engine, its use benefits the construction.

The type of wagon in general use is the 2-yd. dump wagon. These wagons when used for hauling in trains should be equipped with short poles and rods, easily removable when wagons are again used with teams. Many contractors are using the heavier 4 and 5-yd. wagons with tractors for special use. The narrow gage track and cars are used with success where the grade is slight.

There is a tendency among hired team drivers to remove the top box at the slightest provocation, reducing the load carried 25 per cent. A little firmness upon the part of the contractor, when in his judgment the larger load is possible, will affect the result of his work over an entire season.

Some contractors own their own teams. This is rarely profitable, for if costs be carefully kept one season with another, it will be found that on road work there is little if any saving, and the added investment in a hazardous property is a cause of anxiety and often serious loss.

The tools used in grading other than the steam shovel are the drag scraper, the 2-wheeled horse-drawn scraper and the 4-wheeled power-drawn scraper, and the Fresno. All these tools have their special use depending on the nature of the excavation, the length of haul, etc., and contractors of experience are thoroughly familiar with the special application of each.

The use of the Fresno is not so well understood in the East, but in the hands of an experienced man and with teams broken into the work it is adaptable to much of the work of fine grading now usually done with pick and shovel, and at a great saving in cost. Contractors in the west are more experienced in the use of this tool and for that reason grading contracts are done profitably at one-half of our cost. The nature of the earth handled is an important cause, but undoubtedly we have much to learn in this respect.

The road machine is used by most county and village road superintendents, and yet few contractors avail themselves of this tool and it is difficult to find a grade foreman who has other use for it than trimming shoulders. During the past season on a road of light excavation cost was materially reduced by using one of these machines, of the heavier type, drawn by roller, and guided by a man who had handled one for years on county road work.

The jackhammer drill is coming into very general use on road work. This tool may be used with steam, but is much more efficient when used with compressed air. It is available for drilling holes up to 8 or 10 ft. deep. For longer holes the tripod drill is still the best. The churn or well drill is rather for larger work than we usually encounter. In the use of the tripod drill the custom generally is to pipe to the crusher boiler for steam, but a small boiler just for the drill steam is better. Batteries should always be used for blasting.

Where the contract calls for imported stone and in any considerable quantity one of the several unloading devices on the market will prove a saving. It is possible at times to dig a pit under the track, but this often has its drawbacks and in frequent change of location is troublesome and costly. A contractor with an extra or an idle set of stone bins with elevator from his crusher has only to purchase a small gasoline engine to be properly equipped.

In unloading asphalt, and where no trestle is available, a power pump will prove a great saving. In heating asphalt in tank cars the boiler capacity should not be less than 20 H.P. to produce the best results. A smaller boiler used with a super-heater may answer the same purpose.

The latest state requirements necessitate the use of a power distributor for applying the asphalt. It is cheaper and better than the hand pouring even though the latter were allowed.

In the building of State road culverts, or indeed of any small concrete work, the small portable mixers will effect a great saving in labor, and yet many contractors today mix the concrete for culverts by hand.

There are two principal styles of concrete mixers in use for road work—the boom and the spout—but the difference in cost of one or the other, or general results obtained, is rather a personal equation; there is really little choice between them, provided, however, that the mix is of that creamy consistency recommended by the engineers' society.

For curb and gutter and edging the steel forms will afford a material saving. Like all other tools, however, they must be properly cared for or they will warp and bend. The 5-ton tandem roller for brick is usually used and is best, but good work may be done with a horse roller. The concrete wheel-barrows should always be used, as they will pay for themselves in a short time over the ordinary grading barrow. A contractor on this kind of work should be provided with several large pieces of canvas to protect his cement on the work. Where the water has to be brought from some distance the use of a gasoline pump and piping is an economy.

Not enough attention is paid to the matter of the men's quarters. They should be located somewhere near water when possible, and in a healthy and pleasant place. The steel frame bunks with wire springs should be used. One man should be detailed to keep the building clean.

Many times instead of building a camp an idle house or a barn may be available which can be fixed up to make more desirable quarters and usually at a considerable saving in cost.

Maintenance Cost of State Aid Roads in Illinois.—During the year 1915 approximately 409,000 lin. ft. of State aid concrete roads were under maintenance by the State Highway Department. The total yardage was about 559,000 sq. yd. The average cost of maintenance of the concrete slab was 0.4 ct. per sq. yd., or $29.85 per mile. The average cost of upkeep on roadsides and ditches for the concrete roads was $74.75. The oldest road under maintenance was accepted by the Commission in 1914. The average cost of maintenance of the concrete slab in 1916 also was 0.4 ct. per square yard, while the average cost of upkeep (roadside and ditches) was $54 per mile.

MASSACHUSETTS METHODS OF BITUMINOUS ROAD CONSTRUCTION.

The methods employed by the Massachusetts Highway Commission on certain types of bituminous road construction were outlined by Col. Wm. D. Sohier, chairman of the Commission, in a paper presented April 13 at the 4th Canadian and International Good Roads Congress. An abstract of Col. Sohier's paper follows:

Bituminous Macadam by Penetration Method.—We have used both tars and asphalts in penetration work. The methods are much the same. After we have secured an adequate foundation, well compacted and rolled, we have spread on this enough broken stone to make it 4 in. deep after rolling. It has been thoroughly rolled until it will not creep under the roller. On top of this we have spread about 3 in. of 2½-in. stone, and rolled this thoroughly down to about 2 in. thickness. Into this top surface we spray hot asphalt or tar, under pressure, using one of the various mechanical sprayers or trucks. The asphalt has to be heated to about 350° F., the tars to about 250°.

We spray about 1¾ gal. to each square yard of surface, finding that this hot bitumen will penetrate about 2 in., coating the stone. We then spread all the ¾-in. stone that can be rolled in and roll it thoroughly, thus filling the voids in the surface. After this is done all surplus stone is thoroughly swept off with bamboo brooms, and a surface coating of asphalt or tar, ½ gal. to ¾ gal. to the square yard, is sprayed onto the road. This is thoroughly covered with peastone and well rolled. This peastone has to be constantly swept back or more stone added for a few days until there is no sign of bleeding.

When any work of this character is done in cold weather, the road must be carefully watched every warm day, and especially the next season, and wherever there is any indication of bleeding more stone or gravel must be spread on it immediately, or the road will be picked up by the passing vehicles. Covering must always be kept on the road until all the bitumen has been taken up; otherwise teams, trucks, and automobiles will pick up the surface on their wheels.

We spray the bitumen on one-half the road surface at one time, cover it, etc., and then do the other half of the width. The ¾-in. stone and the peastone are got out beforehand and stacked on the roadside, so that the covering can be put on immediately and the stone rolled in before the bitumen cools.

We hope and believe that roads of this character built on an adequate foundation and properly maintained will carry a very considerable traffic for 5 years at least before they need a new surface treatment, when a good grade of the asphalts is used. Where tar is used our experience, in common with the best English practice, seems to show that a light surface treatment of about ¼ gal. to the square yard is advisable and necessary every 2 years.

Wages were so high with us in 1916 that all our costs increased nearly or quite 50 per cent. In 1915 the cost of this penetration work was as follows, for the 4-in. lower course and the 2-in. upper course penetrated with bitumen:

Uxbridge—$1.02 per sq. yd. Trap. Oil asphalt, $0.08¾ a gallon. [illegible]
[illegible]—$1.2[illegible] per sq. yd. Trap. Bermudez, $0.12½ a gallon.
[illegible]—$1.[illegible] per sq. yd. Trap. Tar, $0.0[illegible] a gallon, viscosity, about 125.
Middleton—$0.81 per sq. yd. Local stone. Tar.

The cost of some resurfacing work, penetration method, in 1916 was:

[illegible] and Sudbury—$1.[illegible] per sq. yd. Trap, 6 in. to 7 in. Bermudez, $0.12½ a gallon.
Shrewsbury—$0.98 per sq. yd. Trap, 5 in. Same bitumen.
Northboro—$0.79 per sq. yd. Local stone. Same bitumen.

Tar Sand Grout Method.—Where we have constructed some roads of this character, we have heated our sand and tar on the roadside, using tar kettles and a sand heater to heat the sand. We built a box on wheels, sloping to the end, and had a flexible pipe with a flat nozzle from which the tar and sand mixture was poured into the road.

In Natick, where some work of this character was done in 1914, the old macadam road was scarified, about 2 in. of 2½-in. stone was spread and rolled; this was grouted with the tar and sand mixture, finer stone rolled in, etc., and the cost was about 73 ct. a square yard.

The road has been most satisfactory, and it certainly looks now as if it would last for 10 years at least, on a road with about 50 trucks a day and over 700 motor vehicles.

We have used this method of construction on quite a number of stretches of road, especially on grades, as it seems to be less slippery for horses than any other type of bituminous surface, especially if the surface coat is left off and the stones are allowed to project a little.

The tar and sand seems to stiffen and strengthen the whole road, and we believe the use of the sand prevents the tar from oxidizing for many years, and thereby adds to the life of the road.

We developed this year a very good contrivance for securing an even distribution of the mixture. Two plank bridges were made that bridged the road. They were 2-in. plank supported in the middle on a 2-in. plank on the crown of the road and built up on the sides. Another 2-in. plank running lengthwise of the road was supported on these and the man pouring the mixture walked along this plank, held his bucket right against the plank and walked at a rate of speed that just emptied the bucket in the length of the plank. A flat-nosed bucket was used, with a nozzle about 8 in. in width.

By placing the bridges the right distance apart, one bucket covered just the proper area, and we poured about 2 gal. to each square yard of surface. Keeping the bucket against the edge of the plank secured a straight edge on the road. The plank was then moved along on the bridges across the road, and the process repeated until the whole width was done. There were practically no spaces left where the voids were not filled and the bitumen did not lap.

By keeping the same men on the pouring and having the hot mixture brought to them uniform results were insured and the work progressed rapidly.

Gravel Asphalt Mixed Surfaces.—There are two forms of bituminous construction that we have used with considerable success in Massachusetts, that probably until a year or two ago have not been used elsewhere.

The processes are about the same, except that in one case sand is used combined with asphalt, by either the layer or mixing method, and in the other case a sandy gravel is used combined with asphalt.

We have constructed a good many miles of road where these materials have been used. They make very satisfactory roads for medium and light traffic, and cost comparatively little to build.

We do not claim even for the gravel asphalt road that it is superior to various other forms of bituminous surfaces which cost a good deal more to construct, but that where stone is expensive and the haul long, if a good quality of sandy gravel is obtainable at a very low cost near the road, in many cases a road can be constructed using this material, the first cost of which will be relatively low.

A short description of the process of construction will be of interest. For instance, in Shirley, Mass., a road 18 ft. in width with 3-ft. shoulders, was built, the curves being banked and widened to 21 ft. A gravel foundation was put in wherever the bottom was bad and about 4 in. of local crushed stone was spread and well rolled.

On this was spread, as evenly as possible, about 3 in. of a bituminous mixture, made of gravel that had been run through the crusher and sand or stone dust mixed with a heavy asphaltic product.

The gravel and sand and the asphalt were thoroughly heated and were mixed in a hot mixer, and then carted onto the road and spread. The surface was rolled down to about 2 in. in thickness when the mixture was sufficiently cool not to crawl under the roller.

Great care is necessary to insure a uniform product, uniformly heated, mixed and spread, and that sufficient asphalt is used and no more than sufficient to bind the mixture properly.

The quantity of asphalt has to vary somewhat, according to the amount of voids in the mineral aggregate. The variation is usually from 18 to 22 gal. of the cold asphalt to the cubic yard of gravel. When the mixture is right it has about the consistency of brown sugar and compactness under the roller, though when it is first spread and rolled it sometimes has a few hair cracks which the traffic soon rolls out. The asphaltic product used in this work has a penetration of from 80 to 120 with a Dow penetrometer.

Roads constructed of sand and asphaltic oil were first tried by the Commission in 1905 and the first road is still in existence, though it has required a considerable expenditure each year to keep it up, renew and widen it.

The gravel and asphalt mixture was first tried in 1907, and that piece of road is still in reasonably good condition.

Such mixed asphalt gravel roads certainly look as if they would last for a considerable period of time. Several quite long stretches already have had five years' wear. A few, but not many, weak places occur, and these have to be patched, but the expense is very slight.

A few costs of roads of this character are given below. These costs are all for the 4-in. broken stone base, rolled, with a 3-in. mixture spread on top and rolled to 2 in. The grading, foundation, if any, drainage, etc., were all additional.

COST GRAVEL-ASPHALT MIXTURE.

Shirley (1916)—$0.82 a sq. yd. Residuum asphalt, 8 ct. a gallon
Sterling (1916)—$1.01 a sq. yd.
Gloucester (1916)*—$1.29 a sq. yd.
Andover (1916)—$1.20 a sq. yd.
Reading (1916)—$1.08 a sq. yd.

The asphalt used was a residuum asphalt, usually one with some lake asphalt in it. It cost from 9½ ct. a gallon to 12½ ct. a gallon, depending on the quality. A penetration of about 85 is used for this character of road.

OPERATING COST OF CONCRETE MIXER REDUCED BY ELECTRIC MOTOR.

By attaching an electric motor to a concrete mixer Ryberg Bros., contractors, Salt Lake City, Utah, effected an economy in the first month's operations amounting to more than the cost of the motor. The contractor had a Ransome 10-cu. ft. batch load mixer with a steam engine and boiler. The motor was mounted on timbers extending across the bed frame of the mixer and was connected by a belt to the flywheel of the engine, the piston rod and eccentric of the latter being disconnected from the crankshaft. The boiler was removed. The motor cost $65, and its installation and other work cost $6. The operating costs by electricity for a 25-day month, with the mixer averaging 60 cu. yd. per 8-hour day, was $45. When operating by steam, with coal at $1 per day and engineer at $3.50 per day, the cost was $112.50 per month.

Mixer Run by Electric Motor.

ESTIMATING THE COST OF PAVED SURFACES FOR HIGHWAY IMPROVEMENT.

Contributed by Robert E. Thomas, Illinois State Highway Department.

In some instances where bonds have been issued for road building, or where such action is pending, it has been deemed advisable to conduct the program in two distinct steps: one complete issue for the grading and building of all drainage features, and at a later date, another for the construction of the paved surface. Because of the fact that such surfaces often amount to as much as 75 per cent or 85 per cent of the total financial value of the work, it is imperative that investigation should be made relative to the probable cost of this feature before any concerted action is taken. It is hoped that the following information not only will be of assistance in making such an investigation, but also will furnish a method whereby reasonable results may be obtained without a detailed consideration of every individual element.

Because of the many operations and the several ingredients necessary in constructing a paving slab, it appears feasible to divide the estimate of cost into two parts, namely, that on materials and that on labor.

Materials.

The quantities of materials necessary in building a slab of any type are calculable with comparatively slight chance of error after an inspection of the cross-section to be used, and a study of the specifications relating to the same. This is particularly true for such types as macadam (either waterbound or bituminous) or gravel, where the quantity of stone is merely the volume of the completed slab, increased by an allowance for compaction due to rolling. This allowance will vary with the condition of the subgrade, the quality of the stone and the manner of rolling, but under normal conditions will average approximately 20 per cent. The volume of stone screenings for waterbound macadam is also subject to variation, but can safely be estimated at from 15 per cent to 20 per cent of the total amount of macadam stone required. In the case of screenings for bituminous macadam, a proportionately greater quantity is necessary, and the percentage will probably vary from 20 to 25. Practically all specifications state the amount of bituminous material to be used per square yard for bituminous macadam, so no difficulty will be encountered with this item.

The materials making up a cement grouted brick pavement either with a sand or a sand-cement bed, or of the monolithic type, can be estimated by applying a few well-known principles. By reason of the size of brick usually specified for paving purposes, and the space provided for grouting, it will be found that 40 brick are needed to cover a square yard. For the concrete base it is first necessary to determine the volume of concrete required. By an application of Fuller's Rule, or reference to tables published in any first-class book on concrete, it is possible to secure the quantities of cement, fine and coarse aggregate in a cubic yard of rammed concrete of any desired proportions. In this connection, it might be well to add that the table based upon there being 3.8 cu. ft. of cement in a barrel and 40 per cent voids in the coarse aggregate will most nearly fit average conditions. The product of the total volume in the base and the three figures obtained from the table will be the corresponding quantities of materials necessary. If a sand cushion is specified, the volume is directly obtainable from its dimensions. When the bed is to be a mixture of sand and cement, the quantities of each may be calculated, by using the proper table, in a similar manner to that described for the base. It is practically impossible to compute the quantity of sand and cement to be used for grouting, but experience has shown that a barrel of cement, in a 1 to 1 mix, will cover from 20 to 25 sq. yd. of pavement.

Cement concrete slabs present no difficulty, as the ingredients are computed identically as is the base for a brick pavement.

The materials in a wearing surface of bituminous concrete can usually be computed directly from information contained in the specifications. It may be possible to so modify Fuller's Rule as to make it applicable without gross error to mixtures of this type. The base course of a bituminous concrete pavement is usually of cement concrete or of macadam, and can readily be analyzed by the methods already given.

Undoubtedly some allowance should be made for loss of materials in handling and in transporting, and although a fixed percentage may be greatly in error for any particular case, it is thought that from 5 per cent to 10 per cent for coarse and fine aggregate will represent good practice.

When the estimated quantity of all material has been computed, prices of each F.O.B. the railroad station or siding nearest the improvement site should be obtained. Simple calculation will then permit the total material estimate to be reduced to a square yard basis.

In the foregoing discussion no mention has been made of water, a very important factor not only physically, but, in many instances, financially as well. The availability and cost of water is so affected by local conditions that but few generalities are possible. However, it can be safely stated that a pipe line laid along the right-of-way, supplied by water from nearby streams or driven wells, through the medium of a small pump, will prove uneconomical on types of roads other than those involving the use of cement concrete. When this method is proposed, some use has been made of various formulae for estimating the cost. On macadam and gravel roads where water is applied in conjunction with the rolling, it is customary to haul the water in sprinkling wagons, and in such cases it is usually secured by pumping from streams or from neighboring farm wells. The cost by either method is incurred mostly by labor, and has been provided for in the data under that division.

Table I has been compiled with the object of giving some idea relative to the amounts of materials in highway surfaces regulated by specifications of proven satisfaction.

Labor.

It has been found by combining the estimated cost of the various operations involved in constructing slabs of different types for highway improvement, that the total labor cost, including the team haul on materials, for any rate of labor, or for any length of haul, may be expressed in terms of an equation:

$$P = ALH + BL + CH + D$$

where,

P = total labor cost per square yard in cents.
H = length of average haul in miles.
L = index number representing labor and team rate per hour.
A-B-C-D = constants for a particular type of slab.

The quantity "P" in this equation is graphically represented by the ordinate to a warped surface that had first been defined and located by computing the total labor cost for all limiting conditions. The equation was derived through the assumption of a straight line variation between the computed limits, and this theory has been corroborated by comparison with a number of actual cases.

It was deemed advisable to indicate the labor and team rate by an index, as the numbers involved would be smaller and calculation therefore facilitated. For rates other than are represented in Table II the corresponding indices may be determined by proration.

The estimating data used in establishing the various constants for A, B, C and D, as shown in Table III, are entirely trustworthy for conditions as those existing in Illinois, and have been used for the guidance of bidders on a vast amount of highway work.

Finally, to obtain the total estimated cost per square yard for the slab, it is only necessary to combine the two costs as determined for materials and labor. It must be remembered that no provision has been made, as yet, for profit, so before a final figure is established, an allowance should be made for this item that is entirely commensurate with the work to be done.

As an example, assume that for a particular case it is proposed to improve 4 miles of graded and drained roadway by the addition of a cement concrete slab. Sand and stone are available F.O.B. a railroad siding 1 mile from the nearest end of the improvement at $1 per cu. yd., and cement under the same conditions at $1.65 per barrel net. Assume, furthermore, that the prevailing rates are 20 ct. per hour for labor and 40 ct. for teams. An analysis to determine the probable cost per square yard could be conducted some what as follows:

Materials:	
.313 bbl. of cement at $1.65	$0.52
.092 cu. yd. of sand at $1	.09
.161 cu. yd. of stone at $1	.16
	$0.77
Profit	.08
Total for materials	$0.85

Labor

H = 3 B = 2.909
L = 2 C = 5.005
A = .8341 D = 17.452

P = (.8341 x 2 x 3) + (2.909 x 2) + (5.005 x 3) + 23.452 = 5.0046 + 5.818 + 15.015 + 23.452	$0.49
Profit	.10
Total for labor	$0.59

Total estimated cost for the slab, $1.44 per sq. yd.

There are several items such as depreciation and repairs on machinery, the cost of which is directly traceable to the slab or metaled way, but which has not been included heretofore. Rather than reduce these items to a yardage basis, it is more satisfactory to provide a lump sum covering the whole improvement.

TABLE I.—QUANTITIES OF MATERIALS PER SQUARE YARD OF PAVEMENT.

	Brick (sand cushion).	Brick (sand-cement bed).	Brick (monolithic).	Cement concrete.	Bitu. concrete, concrete base.	Bitu. concrete, macadam base.	Bituminous macadam.	Water-bound macadam.	Gravel.
Brick, No.	40	40	40	....	....	....	....	....	....
Cement, bbl.	.147	.188	.169	.215	.111	....	....	....	....
Bitumen, gal.	....	....	....	....	2.35	2.75	2	....	....
Sand, cu. yd.	.092	.087	.070	.012	.091	.035	....	....	....
Screenings, cu. yd.	....	....	....	....	....	.012	.068	.160	....
Gravel, cu. yd.	.099	.099	.099	.161	.167	....	....	....	.210
Broken stone, cu. yd.	.099	.099	.099	.161	.167	.250	.270	.272	....
Filler, lb.	....	....	....	....	9	9	....	....	....

TABLE II.—INDICES FOR VARIOUS LABOR RATES.

Labor per hr., ct.	15	17½	20	22½	25	27½	30	32½	35
Teams per hr., ct.	30	35	40	45	50	55	60	65	70
Index No. "L."	0	1	2	3	4	5	6	7	8

TABLE III.—CONSTANTS FOR VARIOUS TYPES OF PAVED SURFACES.

Type	A.	B.	C.	D.
Brick: Sand-cement bed or sand cushion	.9633	4.082	5.779	29.494
Monolithic brick	.9051	3.172	5.431	24.032
Cement concrete	.8341	2.909	5.005	23.452
Bituminous concrete, concrete base	.7481	4.353	4.488	30.120
Bituminous concrete, macadam base	.5646	3.664	5.187	22.985
Bituminous macadam	.9189	2.832	5.513	17.992
Water-bound macadam	.8450	2.281	5.070	13.689
Gravel	.6900	1.635	4.140	9.810

MACADAM MAINTENANCE BY SAND COVER.

Prior to the superabundance of automobiles water-bound macadam roads in the Springfield District of the Massachusetts Highway Commission were maintained by keeping a sand covering on them. This required about ½ cu. yd. of sand for every 100 lin. ft. of 15-ft. road. The travel would work this sand to the side of the road, whence it was scraped back to the center of the road again, either by use of 1-horse scraper consisting of a plank set edgewise at an angle with a pair of shafts attached to it or with shovels. It was necessary to make about two applications of fresh sand during the season. The cost of such maintenance was about 2 ct. per square yard per annum. The effect was very good when the automobile traffic did not exceed 200 vehicles a day. The road was, of course, somewhat dusty, though if clean sand was used the dust was not serious. The sand prevented ravelling and gave very good results. Mr. J. A. Johnson, Division Engineer at Springfield, advises that under present day conditions, however, there are no roads in the district where the auto traffic is as light as 200 vehicles a day, consequently the sand treatment has been abandoned and all roads that are not built with bitumen or concrete are now oiled.

REDUCING RURAL ROAD CONSTRUCTION COSTS BY INCREASING EFFICIENCY OF OPERATION.

Some excellent suggestions for increasing the efficiency of the various operations in rural road construction were given by Wimund Huber, Assistant Engineer, Ontario Department of Public Highways, in a paper presented March 30 at the Third Annual Conference of Road Superintendents and Engineers of Ontario. The paper was divided into two parts: efficiency of operation and efficiency of organization. An abstract of the paper dealing with operation follows:

The efficient working of any road building organization requires that the various branches of the work which are dependent on each other, quarrying, crushing, hauling, rolling, etc., shall so be arranged that each individually is working to capacity, but is not hurried in such a way as to encourage inferior work. The crushing outfit must deliver all the material which the roller can consolidate satisfactorily; if less stone is supplied the roller will be idling part of the time; if more, the stone will receive less rolling than it requires, and ravelling and rutting will probably follow. For the same reason the number of teams used to haul the stone must be adjusted to suit crusher output and length of haul. If more material is crushed than can be consolidated by the roller, the surplus should be stored in a convenient stock pile to be drawn on in case of breakdown or delay to the crushing outfit. If the roller is delayed or falls behind the crusher the stone should be placed on the stock pile rather than strung along the road far in advance of the roller.

Where stone is imported by rail, the maintaining of a stock pile is an absolute necessity. It has been found by experience that, even though the material may be shipped from the quarry promptly and the different sizes shipped in correct proportions, the railroads will not deliver it in the same proportions or with the same regularity, and unless a considerable quantity of each size is kept on hand, delays for want of stone of some particular size will inevitably occur.

The first operation in the construction of a section of road is usually that of grading. Wherever grading can be done in reasonably long stretches the employment of a traction engine will be found economical. The cost of operation of a tractor is approximately equal to the wages of two teams, or one may usually be rented during the spring and early summer for a similar amount. Ordinarily the amount of work done will be from 25 to 50 per cent greater than can be accomplished with teams, due to greater tractive power and the elimination of periods of rest. If teams must be used they should be teams with previous experience at the work. In fact the operation of grading is one requiring experience in both men and teams. Not only is poor work sure to be done by inexperienced men and horses unaccustomed to the work, but positive damage may result. In no branch of road work is the wisdom of the permanent and continuous employment of men and teams better exemplified than in the operation of grading.

Where the removal of large quantities of earth is concerned, in such operations as filling and hill cutting, careful attention must be paid to the method of handling. For very short distances, up to, say, 150 ft., drag scrapers may be profitably used; above that distance, to about 500 ft., the material can usually be most advantageously handled in wheel scrapers; while for longer distances dump wagons will be found more economical. There is frequently a tendency to adhere to the use of drag scrapers in the transportation of material for distances far too great for economy.

Another point to which more attention might be given is the selection of teams for use with scrapers. Light soil and sand are moved more economically by light teams, whose quicker movements permit the handling of more material in a given time. The loosening of all soil, except the very lightest, with a plow before attempting work with scrapers, will also lower the cost of moving the material.

In quarrying and crushing operations money may be saved by carefully watching individual operations and seeing that maximum results are obtained for every expenditure of money or work. In the case of quarrying, the end desired is the loosening of rock, and as most of the expense of quarrying is made up of the cost of drilling and the cost of dynamite the condition under which the greatest amount of rock can be displaced with the least amount of drilling is the condition of greatest efficiency. For this reason the only satisfactory man to have in charge of a quarry is a practical quarryman.

The operation of crushing stone for road building affords a good opportunity for the study of scientific management. Usually the laborers engaged in this class of work are not in the habit of thinking very hard for themselves, and the duty of seeing that each man works to advantage will fall almost wholly on the foreman. First of all, the capacity of the crusher itself must be such as to deliver the stone in sufficient quantity to keep the roller busy. A crusher having a capacity of 100 cu. yd. of 2-in. stone per day has been found most satisfactory. Whether the material be fieldstone or quarried stone there is usually little difficulty in delivering to the crusher all it can crush. The real problem is to keep down the cost of this delivery to the crusher. Lifting the stone by hand should be eliminated whenever possible. The lifting of stones from wagons is a wasteful and laborious method, and is rarely employed when low costs are of first importance. Since the material must usually be delivered to the crusher in wagons, carts or cars, it might just as well be delivered as nearly as possible into the crusher jaws, and so, to as great an extent as practicable, reduce the cost of handling.

Whenever possible the stone should be delivered on a platform at the level of the top of the crusher jaws. Under ordinary conditions the cheapest moving of stone from the pile or quarry to the crusher is accomplished where handling by men is reduced to a minimum. Such results are usually secured with dump carts and an incline leading to a platform from which the stone can be dumped directly into the crusher. Even lower costs will be obtained through the use, where practicable, of dump cars running on portable tracks from the face of the quarry to the crusher. For best results the track must have sufficient grade to permit the loaded cars to be pushed by one or two men, but not so much as to prevent the empty cars to be pushed back by the same men. The tracks must also be at such an elevation that the stone may be dumped on the platform level with the top of the crusher jaws. In order that no delay may occur two tracks should be laid and two cars operated, one to each side of the crusher; such an arrangement will insure continuous work both at the quarry face and at the crusher.

The prime essentials to rapid crushing are keeping the jaws filled and the rejection of stone too large to be handled by the crusher. When stone is delivered on an elevated platform, one or two men can easily keep the jaws completely filled, whereas in handling from wagons or piles five or six men have frequently been observed doing the same work, and the results were not so satisfactory. Stone in too large pieces reduces the output by causing frequent short delays, and the breaking of these large pieces with a sledge is liable to injure the machine. Blocking up the crusher off its wheels will increase the output by reducing the vibration and will also prevent undue wear on the axles. Since much of the cost of wages in connection with crushing operations is for teams, the organization should provide for the reduction of their number to a minimum. This may be accomplished by supplying extra carts and wagons, so that the teams are not required to stand idle during loading operations.

The argument for keeping teams moving applies with even greater force to hauling operations. The wage of a team is from two to two and a half times that of a man, and lost or wasted time consumes a lot of money.

For this reason alone the employment of spreading wagons will effect a considerable saving over the use of the ordinary wagon with gravel box. But, spreading wagons possess other advantages. In addition to the saving of approximately five minutes in dumping each load and the better spreading of the material these wagons, which are constructed with a definite capacity, will insure the hauling of a uniform quantity at a load, and permit accurate and rapid calculation of the total quantity hauled.

The discussion of methods of cost reduction would be incomplete without a reference to at least one important factor on which much of the efficiency of hauling depends, viz., the size of the load to be drawn. Over fair roads it has been shown time and again that a good team can draw 2 cu. yd. of crushed stone without difficulty. Teams which cannot do this should be discarded as unprofitable. Under no conditions should a load of less than 1½ yd. be tolerated. In certain counties of Ontario, a load of ½ cord, or over 2⅓ yd., is insisted on, and no difficulty has been found in securing teams which would haul this load. Payment for hauling by the yard-mile has been found to work satisfactorily, among its advantages being the facts that an incentive is given the teamsters to deliver the material more expeditiously, and that the cost of hauling can be more accurately estimated in advance.

The size of the load is frequently governed by the grades to be traversed, and it often happens that the load is considerably reduced on account of a single steep hill or difficulty in pulling out of a deep gravel pit. In many such cases full loads may be drawn if a horse or team is stationed at the hill or exit from the pit to assist the loads over the difficult places.

It is frequently necessary to haul stone or gravel a considerable distance over ordinary township roads in poor condition. In such cases the cost of haulage may be reduced by the judicious use of a grader or drag, or even the employment of a roller for a day or two, to consolidate the road and produce a surface which will offer less resistance to traction. A reasonable amount of preliminary work with a view to facilitating or reducing the cost of any operation is sound practice and will more than pay for itself.

The possibilities of traction haulage are becoming more generally realized, and since it has been shown that the cost of transporting road building material may be reduced to a small fraction of that of team haulage, especially on long hauls, the subject is bound to receive in the very near future the attention it deserves. The cost of hauling with teams is between 20 ct. and 40 ct. per yard-mile, depending principally on the rate of wages, condition of road and length of haul, with an average on country roads from 25 ct. to 30 ct. With a traction outfit the cost has, under very favorable conditions, been reduced to less than 5 ct. per yard-mile, while an average cost might be placed at from 8 ct. to 12 ct. per yard-mile or less. Since the cost of transporting materials constitutes a large percentage of the final cost of the road, it is easily seen that a saving in hauling costs such as the foregoing will be a long step toward cost reduction.

Having delivered the material to the road, the next step is its consolidation, and as in all other operations, the less work wasted, the more cheaply it will be done. Probably more work is done to no purpose in the work of rolling a road than in any other operation. The rolling must be so performed that every passage of the roller accomplishes something in the final consolidation of the stone, and to this end it is imperative that a thoroughly qualified man be in charge of the roller. With careless or inefficient handling, the roller may on one passage partly undo the work of the former passage, and not only will the work required for final consolidation be increased, but the individual stones comprising the road surface will become rounded from the excessive grinding on each other, and the final result will not be so satisfactory. In order that the sharp edges of the stone may be preserved as much as possible and thus tend to prevent internal movement, the less rolling the stone receives, consistent with thorough consolidation, the better. Rolling is a science and must be carefully studied in order to secure best results.

For efficient consolidation the road must be finished as the stone is delivered. The practice of laying long stretches of stone and partly rolling the whole length is wasteful of labor, since much of the work of rolling is undone by traffic passing over the partly rolled stone. The closer the end of the finished road can be kept to the wagons delivering the material, the more cheaply will the work be done. This is especially true where a temporary road cannot be furnished and where traffic travels on the new road before and during rolling.

Wherever possible rolling should be commenced with the whole width of the roller, except the inner rear roll, on the earth shoulder. This is for two reasons: the earth shoulder is rolled at the same time as the metalled portion, and the stone is consolidated first at the outside, retaining the desired crown. By rolling back and forth, working slightly toward the centre at each trip, say 6 in., or approximately one-third the width of the rear roll, the stone is gradually consolidated without forcing it outward or reducing the crown.

To secure satisfactory consolidation the stone must be confined at the sides, in the same way as a curb confines the material on a city street. No matter how carefully the rolling may be done, the loose stone exhibits certain of the properties of a liquid, and pressure exerted on any part of the surface is transmitted through it and tends to force it out at the sides. Unless this lateral movement is prevented, satisfactory compacting of the stone cannot be secured. Another advantage attending the confining of the stone at the sides lies in the fact that a substantial depth of metal is retained at the edge instead of a thin edge which is so easily broken off, usually resulting where stone is deposited on the surface and allowed to spread with rolling. The stone is also consolidated with the width originally intended, not 1 to 3 ft. more, with a corresponding decrease in depth.

Where the road has been freshly graded, and where no stone or gravel has been formerly applied the centre of the road may be trenched out with the grader, leaving a shoulder of earth at each side. The stone is deposited between the shoulders, and stone and earth shoulders rolled together. Where it is deemed inadvisable to disturb an old stone or gravel surface, the new material may be deposited in the centre, and an earth shoulder drawn up with the grader, and earth and stone rolled together as before described. Where the old metal surface extends beyond the width of the new metal, or on hard clay roads where the operation of the grader is difficult, small trenches 6 in. wide and 4 to 6 in. deep may be picked in the subgrade to hold the edges of the stone, and the shoulder thus formed will keep the metal within the desired width.

Having in view the fact that the efficiency of rolling operations depends largely on keeping the roller working, it is well to remember that anything which tends to retard the roller's work destroys its efficiency. Frequently a serious retarding influence is lack of water for flushing the road. Whenever the water used for this purpose must be hauled a considerable distance it will be well to have two tanks in commission, in order that the roller may not be held up while waiting for the return of the tank. The time lost through this cause will amount to a very considerable total, whereas the cost of operation of an extra tank is negligible.

The application of the water to a road during construction may seem an unimportant item, but on it depends the success of the work, and the quality of the finished road. Moreover a considerable part of the cost of this part of the work may be saved and better results obtained by careful management. The old method of filling the tank with a hand pump has been superseded in many up-to-date outfits by a power-driven pump operated with a gasoline engine. The tank is filled in a fraction of the time required to do the work by hand, the difference being most noticeable in hot weather, when hand pumping is very laborious.

The same power-driven pump may be used to effect still another saving when putting the water on the road. Instead of hauling the tank back and forth ahead of the roller it may be placed at the side of the road in the middle of the section to be finished, say 125 ft. in length, and with a 50-ft. length of 1-in. hose the water may be applied wherever required on that section. When one section is finished the tank may be drawn ahead to the next by the roller. The amount of water used by this method is less than by the ordinary method, since it is applied only where needed and none is wasted, less being allowed to run off the sides, or sink into the subgrade. The continuous employment of a team on the tank is dispensed with, or, where two tanks are employed, the team may be going for one tank of water while the other is being emptied. Another important feature of this method is the fact that the stone is not disturbed by the horses or tank traveling over it and turning on it, and the roller's work is not thereby partially undone. Also that the roller and tank do not get in each other's way, causing frequent short delays. The same results may be obtained even with a hand pump, but are not quite so satisfactory or economical since the services of one or two men are required on the pump. Watering should be done in short sections, particularly in hot weather, from 100 to 125 ft. having been found a satisfactory length. Where the sections are too long the heat may cause the evaporation of the water almost as fast as it is applied and much loss be occasioned thereby.

ASPHALTIC CONCRETE BINDER FOR SHEET ASPHALT AT CHATTANOOGA, TENN.

In two repaving jobs last year at Chattanooga, Tenn., asphaltic concrete was used to regulate the grade and cross-section of the old base, and to serve also as the binder course for the sheet asphalt surface. The work was done under two separate contracts. The first embraced parts of three different streets on which there were old brick pavements with an aggregate yardage of 14,000, and the second contract was for resurfacing over an old asphalt block pavement laid in 1891, covering a yardage of 15,100. On two of the streets included in the first contract there were old vitrified brick pavements laid in 1892, 24 years before. These old brick pavements were laid on a cement concrete base, 6 in. in thickness, and had a 1-in. sand cushion.

The specifications for the new work called for the removal of the old brick and sand and the thorough washing by means of hose attached to the fire hydrants of the surface of the old concrete. Vitrified brick gutters, 30 in. in width were laid on each side of the roadway. A layer of compressed asphaltic concrete was laid on the old concrete base, for the entire width between gutters, of such thickness as would bring the surface thereof within 2 in. of and parallel to the surface intended for the completed pavement.

The thickness of the asphaltic concrete was 1½ in. along the center of the roadway and 2½ in. at the gutter, averaging about 2 in. On this was laid the 2-in. sheet asphalt wearing surface. One of the two streets mentioned was a business street along a portion of which was a double car track and having a width between curbs of 46 ft. The other street was a residential street and an important thoroughfare leading from the center of the city to the suburbs. The curbs on these two streets were not removed except at the corners of intersecting streets, which were rounded off with concrete curbs of 6 ft. radius. The contract prices for the work were: Sheet asphalt, including binder, 92 ct. per square yard; brick gutters, $1.50 per square yard; removal of old brick and sand, 9 ct. per square yard.

The third street included in this first contract consisted of two short blocks. On this street the old concrete base was used in part, a strip of new concrete being required along the center of the roadway, from which the rails of a car track had several years before been removed and the old cross-ties left in. An average thickness of about 2 in. of asphaltic concrete was required to true up the surface of the old concrete. A 2-in. sheet asphalt wearing surface was laid on this street, which has recently developed into an important retail business street. The important feature connected with this improvement is that one block is on an 8.8 per cent grade. This asphalt pavement has been in use for more than a year and no complaint as to slipperiness has been made to the engineering department.

The second contract provided for laying an asphalt surface over an old asphalt block pavement laid in 1891. This pavement originally consisted of asphalt blocks 5 in. in depth laid on a 2-in. sand cushion with a 1-2-4 cement concrete base, 6 in. in thickness, natural cement being used. The old pavement after 25 years' use had become worn down 2 in. or more in the middle portion, but very little next to the curb.

The irregularities in the surface of the old pavement were eliminated by the application of asphaltic concrete of such thickness over different portions of the roadway as was required to bring the surface of the layer when compressed, to within 1½ in. of and parallel to the surface intended for the completed pavement, all holes or depressions of small area being filled with asphaltic concrete and hand tamped in advance of the application of the final layer, which was compressed with a steam roller.

When the asphaltic concrete had thus been laid for the extent of two blocks the asphalt wearing surface, 1½ in. in thickness after compression, was laid. Before drawing the specifications for this work cross-sections were taken every 25 ft. along the 3,600 lin. ft. of street to be surfaced with asphalt, rod readings being taken every 4 ft. across the roadway. The cross-sections were plotted, the curve for the finished pavement drawn in on each cross-section and the areas between this curve and the surface of the old pavement computed. From these areas the average depth from the surface of the finished pavement to that of the old pavement was computed. This average depth in the case of this particular street was 3.51 in. As the wearing surface was to be 1½ in., this left 2 in. for the average thickness of the asphaltic concrete binder. This information was furnished to bidders in the specifications with the statement that the average depth given did not include small depressions in the old pavement between the cross-sections, but that the price per square yard bid for the new surface would include such depressions, the bidder making his own allowance therefor. These depressions probably did not affect the general average depth by more than ⅛ to ¼ in. Five bids were received for this work, the average of which was $1.26, and the lowest $1.00 per square yard. The contract was awarded to the lowest bidder.

So far no unsatisfactory results have been developed in any part of the work included in these two contracts. Oil asphalt was used throughout. The low prices bid was due in a measure to the fact that the first contract was let in the fall of 1915, when the price of asphalt cement was low and the second contract was let to a paving company which had previously contracted for asphalt at a low figure. The same work now would perhaps cost 50 per cent more than the prices paid.

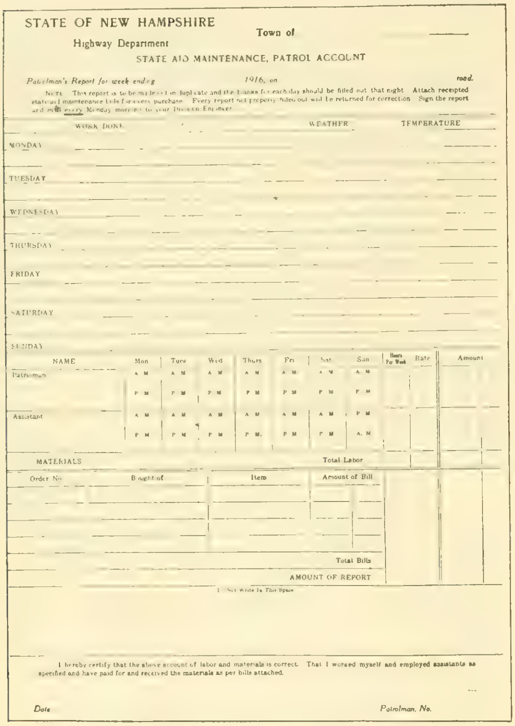
In laying an asphalt surface upon an old concrete base laid many years ago for carrying a brick or some other form of pavement there are usually irregularities of surface in the old concrete which it is important to eliminate. In such cases the asphaltic concrete binder is so applied as to regulate the grade and cross-section, care being taken to fix the grade of the surface of the binder coat so that its thickness shall not at any point be less than 1½ in. This will of course make the average thickness exceed 1½ in. When the surface of the old concrete is at a sufficient depth below the grade designed for the new pavement to permit the building up of the old base with 2 or more inches of new concrete this plan is resorted to.

The work described above was carried out under the direction of Robert Hooke, City Engineer.

THE NEW HAMPSHIRE PATROL SYSTEM OF GRAVEL ROAD MAINTENANCE.

By means of the patrol system of maintenance New Hampshire is able to keep its gravel roads in excellent condition at very low cost, considering the destructive use to which they are subjected. These roads throughout the summer are used by a heavy automobile traffic, particularly on Saturdays and Sundays. During 1916 the state employed 225 patrolmen and practically every section of state-aid road was under patrol. The following information regarding the New Hampshire system is taken from the Road Patrolmen's Handbook of Instructions and Regulations, issued by the state Highway Department, of which F. C. Everett is the Commissioner:

Each patrolman is required to provide himself with the following outfit: A single horse and dump-cart and a shovel, pick, hoe, rake, stone-hook, axe, iron bar, iron chain and tamp. Special tools and implements are provided by the State Highway Department.



STATE OF NEW HAMPSHIRE

Highway Department

Town of

STATE AID MAINTENANCE, PATROL ACCOUNT

Patrolman's Report for week ending 1916, on road.

NOTE. This report is to be made out in duplicate and the blanks for each day should be filled out that night. Attach receipted state aid maintenance bills for every purchase. Every report not properly filled out will be returned for correction. Sign the report and mail every Monday morning to your Division Engineer.

	WORK DONE	WEATHER	TEMPERATURE
MONDAY			
TUESDAY			
WEDNESDAY			
THURSDAY			
FRIDAY			
SATURDAY			
SUNDAY			

NAME	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Hours Per Week	Rate	Amount
Patrolman	A. M.	A. M.	A. M.	A. M.	A. M.	A. M.	A. M.			
	P. M.	P. M.	P. M.	P. M.	P. M.	P. M.	P. M.			
Assistant	A. M.	A. M.	A. M.	A. M.	A. M.	A. M.	P. M.			
	P. M.	P. M.	P. M.	P. M.	P. M.	P. M.	A. M.			
								Total Labor		

MATERIALS

Order No.	Bought of	Item	Amount of Bill	
			Total Bills	
			AMOUNT OF REPORT	

Do Not Write In This Space

I hereby certify that the above account of labor and materials is correct. That I worked myself and employed assistants as specified and have paid for and received the materials as per bills attached.

Date *Patrolman, No.*

Fig. 1—Form for Weekly Report of Road Patrolmen.

Each patrolman gives his constant attention to the maintenance of his section and patrols it every day, rain or shine (Sundays and legal holidays excepted), and is responsible for the section in his charge. Less than full time patrolmen are governed by their schedules for number of days to work each week.

The patrolmen keep all culverts, ditches and waterways open and free from obstructions, all loose stone and rubbish removed from the road, guard-rails safe and painted, and the brush and vegetable growth cut from beside the road and on the inside of all curves. Especial attention is given to promptly removing all glass bottles and broken glass from the roadway and beside the road.

Each patrolman is provided with blank reports (see Fig. 1) which he is required to fill out and forward weekly to the Division Engineer. He is also provided with postal cards to use in making special reports during the week.

Patrolmen are expected to keep their sections in proper condition at all times throughout the season, and are paid Emergency work, nights or Sundays, is allowed extra.

Emergency work, nights or Sundays, will be allowed extra.

There is no allowance made for overtime, nor is there any "docking" for short time. There is no time clock on the work but the department treats this matter of hours on a man-to-man basis and looks to each patrolman to give his work and the taxpayers a square deal.

There is one requirement that all patrolmen are expected to live up to and that is that they shall be on their sections ready for work at seven o'clock in the morning. They may commence earlier than this if they wish, showing the time on the report and any accumulated time in the morning before seven, or by taking one-half or three-quarters of an hour at noon, or by working after five at night can be taken off Wednesday afternoon. Time does not accumulate for more than one week. On a very stormy day, when the patrolman has been all over his section, and is through work at three or four o'clock, he will state the fact on his report, but will carry out a full day's pay, and in return the department looks to the patrolman to give it the benefit of an early start or a little later work when the patrolman is working at the far end of his section to balance up the short days.

Every patrolman is expected to go over his entire section and carefully inspect it every Saturday, filling the holes, picking up stones and doing what work is necessary to have his road in the best possible condition for the Sunday travel. There is no exception to this rule except by written orders from the Division Engineer.

When a man takes part of a day off for his own use he will so state, and will be paid for such part of a day as he worked on the road.

Every patrolman should be very particular in showing the actual time when he begins and stops work for each day for his own protection as well as for the information of the department.

The time of all patrolmen is made up from the weekly reports and every week an order is sent to the patrolman for him to present to the selectmen, who will give him a town order on the Town Treasurer. This order will include, besides the patrolman's pay, all money he has paid out the preceding week for supplies or assistants. Thus, all patrolmen will receive their pay regularly either weekly, bi-monthly or monthly, according to arrangements they may make with the selectmen.

In the lower left-hand corner of the state order is a memoranda showing the number of days, etc., covered by the order. Patrolmen are expected to verify this with their accounts for that week and, if wrong, to notify the Division Engineer before presenting the order to the selectmen so any mistakes can be corrected before the order is paid.

When purchasing supplies or materials patrolmen must proceed as follows:

a. The patrolman will first get an order from the Division Engineer for the purchase of all supplies and materials. This is done by stating on a postal card, under "Remarks," what is wanted, quantity and probable cost.

b. When making the purchase he will have the bill and duplicate made out by the seller on the proper blue, pink or green billhead, and when the patrolman has paid the bill and had both the bill and duplicate receipted, he will fill out the lower left-hand corner and attach one receipt to each copy of the weekly report.

c. All receipted bills must be sent in to the Division Engineer promptly at the end of each week, and the refund for the amount paid out by the patrolman will be included in next pay order.

d. In cases of emergency authority to make a purchase may be obtained by telephoning the Division Engineer and the order will be sent by mail. Unless an order has been given authorizing the purchase of materials a patrolman makes the purchase at his own risk.

Every patrolman is provided by the department with two cart signs and one staff, all corresponding to the number of the patrolman. They must not be changed or mutilated in any way.

The signs are to be attached, with small screws, to the seat-box of his cart, one sign on each side.

The staff is to be carried in an upright position on the front right-hand corner of the patrolman's cart at all times except as follows: Whenever the patrolman leaves his section so his cart is not noticeable from the road, as in a gravel-pit, off the end of his section, or for any other purpose during working hours, he is required to stick his staff in an upright position, with the flag at right angles to the center of the road, where he leaves his section and where he will return to it again. When hauling material the staff is left beside the road when the patrolman is in the bank, but on returning to his section with his load the staff is again placed on the cart and carried until he returns to the pit.

On stormy days when a patrolman is on duty with a carriage or vehicle other than his patrol cart, he will carry the staff in the whip socket to show he is on state work.

In every division there is a maintenance foreman who has immediate charge of all maintenance work under the direction of the Division Engineer.

The maintenance foreman will work with and assist all patrolmen and give instructions, suggestions and advice. He will inspect all sections from time to time, and it is for the interests of the patrolmen to take up all parts of the work on which they are uncertain so as to get the greatest benefit from these inspections.

If a patrolman desires advice on a particular problem of his work during the season, he is expected to notify the Division Engineer,' who will send the maintenance foreman to help him out.

Suggestions and Pointers.

As a general rule, plan your work so as to begin at the far end of your section the first of the week and work towards home, commencing each day where you left off the night before. Give your entire section equal care and attention.

Plan your work so as to spend the greatest possible amount of time in actually doing maintenance work and the least possible time in traveling around. Don't get the habit of simply riding over your section—you not only lose valuable time but it makes a bad impression on the taxpayers.

Don't stop and talk with everybody who passes by. A man who kills time kills his work and "short stories in hay-time" applies to road work as well as to farm work.

Save all the sods, leaves, rubbish, stones and refuse that you clean off your road and dump this waste material in places where the bank is steep, so by flattening the side slope there will be no need of a guard-rail, or dump the material back of a present guard-rail so that later this guard-rail can be removed.

All brush, after cutting, must be removed from the sides of the road or placed in small piles and burned. Under no condition should a patrolman dump brush off the side of his section where there is danger of it being set on fire by the traveling public. In cutting brush all trees four inches or over in diameter should be left for shade purposes unless ordered removed by the Division Engineer. August is the best month for general brush cutting. Find out the location of all suitable surfacing material on your section and arrange with the owners to sell it to you. It is better to get four loads of good dirt on a short haul, even if inferior to good gravel, than only to be able to get one or two loads because of the long haul. Fill the holes and ruts with the poorer material and then put a light coat of gravel on top—it will save you time and you can fill more holes in a day. If you have a large stone or log to get out of your road, have a load of earth in your cart or dumped near by before removing the obstruction so you can quickly backfill the hole and not inconvenience travel any more than necessary.

Never dump any material directly onto your road or in a hole or rut. Always dump on a dumping-board or shovel the material out of the cart. If for future use, material can be dumped in piles on the shoulders or side of the road and then, when needed, shoveled onto the road surface.

Drag early. One dragging in the spring is worth two in the summer. Don't try to drag all the road at one time—take a certain section and first put that in shape, dragging two or more trips if necessary. Make the most of the weather conditions and drag when the surface of the road is wet—after a rain—so your drag can move material. Don't drag a soft section when it is so wet that the first vehicle to pass will rut it all up—first fill the holes and ruts with new material and then drag as the surface dries out. Clayey sections should be kept well crowned up to shed the water, and sandy sections should be as flat as possible to hold the rain water. The reason, a clay road is best when dry while a sand road is best when damp. Every patrolman is expected to work on rainy days and should provide himself with suitable coat and boots to keep dry. On days when it is raining very hard, he may patrol his section in a light hitch and see that all ditches, culverts and waterways are free and carrying off the water, and at this time he should locate and mark all holes where water is collecting so that he can fill them as soon as the rain lets up. On all other rainy days the patrolman is expected to use his regular cart and outfit, and every patrolman should have material dumped in small piles along the side of his section so that on a rainy day he can at once fill all holes and ruts in which water is collecting. The very best work on any road can be done when the road surface is wet, both in filling holes and ruts with new material and also in dragging the road as the surface dries out.

Make a study of your road so you will know the weak and bad places and then use your best judgment in repairing them. Take your dinners with you and plan your work so as to lose the least possible time in traveling.

Remember it is not a sign of weakness or failure to ask questions or seek advice. If you do not know what to do, do not be afraid to ask your engineer or maintenance foreman—they are as much interested in you and your work as you are yourself, and it is their business to answer questions and help you in your work at all times.

Make "Better Roads" your slogan and all patrolmen join with the department in a united movement to make it come true.

MOTOR TRUCK TRAILER IN STATE HIGHWAY WORK.

The accompanying illustration shows a trailer installation used by the New York State Department of Highways in connection with its road work. The trailer illustrated is of the 5-ton capacity reversible type, made by the Troy Wagon Works Co., Troy, O. It is equipped with 7-in. rubber tires and has a 4-yd., 2-way side dump. The photograph shows the trailer being hauled by a 3-ton Packard truck.

Five-Ton Troy Trailer in New York Highway Work

THE CONTRACT AND SPECIFICATIONS FOR PAVING.*

In the first place, the contract should be in the nature of an agreement between equals; one of whom is ready and willing to deliver the goods specified, the other ready and willing to pay the prices stipulated. Many, in fact, most of the paving contracts that I have examined, and some that I have been bound by, more nearly resemble a master-and-slave contract. The engineer, especially if he is a man of superficial understanding, always poses as master to the contractor's slave. Since freedom-of-contract is very largely a legal fiction, one should not be surprised to learn that as soon as they have signed such one-sided documents, most contractors have the feeling that anything they can get away with is theirs. Some engineers—and I have one in mind who rode on my neck for several unpleasant months—do not even admit that their interpretation of the contract must necessarily be reasonable. The contractor, especially if he is a man of small finances, must often grin and bear this attitude of the engineer, denying himself even the luxury of telling the man what he thinks of him until the work is completed and the money collected.

Now such a condition of affairs is not conducive to the best results in road building. No matter how clever an engineer may think himself, the contractor who feels that he is being badly used can deliver and collect for a job that is much less than the best that is possible under the agreement, even though he save no money to himself thereby. Inversely, an engineer who is ill-disposed to the contractor working under him can always cause more expense than is actually required to do the work properly, especially if such engineer is armed with the too common poorly drawn specification coupled to the master-and-slave form of contract. While it is true that the interests of the contractor and the interests represented by the engineer are opposed in the major premise, there is no reason why both parties should not candidly recognize this fact, and then go ahead with the least friction possible to the building of a good road. One of the prime necessities of team work between engineer and contractor is that each thoroughly understand and respect the rights of the other. As a basis for this there must be the well-drawn and easily understood contract and specification in which what each party has agreed to do is clearly stated. Enough unforseseen details will then crop up during the progress of the work to call for the exercise of good sense and a sweet temper between even well disposed men.

No engineer is fully competent to draw a road or street paving contract until he has made certain preparatory moves. We will assume that the selection of the road site and the proper attention to drainage are accomplished facts, that the traffic is sufficient to warrant a hard road surface, and that the money can be made available. It is up to the engineer to determine what kind of pavement can be laid to the best advantage, and to draw a contract and specification therefor preparatory to accepting bids from contractors. If the work is to be done by direct employment, the contract form may be dispensed with; but the specification should not be omitted, though it may be shortened. There is no reason why public employes doing road work should not live up to just as strict specifications as would be imposed upon a contractor doing similar construction.

It is doubtful if any two paving situations are identical, though most of them closely resemble each other in many important details. Therefore, prior to making the important decision as to what type of pavement to lay, the engineer should very carefully study all the different forms of construction that are possible, the available materials therefor, and the costs and other factors involved. He should be thoroughly conversant with not only the prices that have been bid by contractors at previous lettings in his neighborhood, but, by having made his own careful detailed estimates of actual costs of labor and materials he should also be in a position to know if the prices formerly charged were reasonable, and whether or not he can lower them by good management and fair dealing.

In many contracts, it is stated that certain things must be done when the engineer has no intention at all of demanding them, and other things are expressly prohibited that in practice the engineer will quite properly permit. Such a contract is not fair to the contractor. What is necessary should be stated; what is not necessary should be omitted. The requirement for planking a concrete foundation to haul upon it after it has been down seven days is such an instance. Few engineers enforce this clause, and if one did I should be very suspicious of the quality of his concrete. Any pavement foundation that has set seven days and will not then carry without risk the hauling incident to further construction is not fit to accept. Planking grade is also frequently required in the contract when it is unnecessary and not demanded in practice; unless, perchance, the engineer wishes to punish his "slave." Can one blame the slave if, in order to get even with his "master" he stays awake nights devising a scheme by which he can use two bags of cement instead of three under his master's very nose? This is being done every day, but, sad to relate, it is the public and not the engineer that sustains the loss.

In drawing the specification, the rule should be: A reason for everything, and everything in its place. Can engineers much longer go on specifying things that they do not understand? The unfortunate attitude of many public bodies in thinking that, because they have hired a man who is a graduate engineer, he should be able to solve every problem submitted to him without special assistance, is the cause of more poorly drawn specifications than anything else. I have sometimes noticed that the smaller the salary an engineer receives the more he is expected to know. The poorly paid village engineer, who is expected to know it all, and is thought to be too expensive even at that, finds himself compelled to get along as best he can alone in order to hold his livelihood. The result is a brave attempt at a specification that is taken in chunks from standard and other specifications, and through which, when it comes to a law suit, the contractor and his attorneys can drive a team of horses at most any point. It is all that could have been expected from the engineer under the circumstances. Family doctors are not expected to perform appendix operations, and those who require it of them must expect to suffer in the process of cutting.

As paving engineers, why do we ask a contractor to guarantee the work that we design, direct and inspect? We tell the contractor what to do, how to do it, and when. If the pavement goes wrong—barring absolute fraud of course—why should the contractor pay the penalty? Fair play demands that the engineer guarantee his own road. I do not mean to actually suggest that he be asked to give a bond and make good the loss, but that the contractor should not be required to make good a failure if it is in no way his fault. The engineer's reputation should suffer, not the contractor's pocket, and through him the public's. If this rule held true, engineers would be much more careful in the paving work that they specified and constructed. I have noticed that the contracts which leave the contractor with the least to say how the work shall be actually done, also frequently bind him the tightest with a guarantee of the result. This is an element of chance that is forced upon the contractor, and, as with everything else, he of course figures on it in his bid.

Mr. E. M. Perdue of Kansas City has remarked that the guarantee is a two-edged sword which cuts the taxpayer both ways. Mr. J. W. Howard of New York City opines that what we want are good pavements on our streets, not guarantees on paper. I agree with them both. The practice of requiring a 5 or 10-year guarantee on paving work has done much harm in the past, and will probably live enough longer to do more harm in the future. It has been the excuse offered by innumerable city officials for not bothering about good inspection and careful testing of materials, and it has been productive of more expensive law suits between city and county governments and contractors than any other one item.

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*Abstract of a paper presented April 13 before the fourth Canadian and International Good Roads Congress by Charles A. Mullen, director Paving Department, Milton Hersey Co., Ltd., Consulting Engineers, Montreal, Quebec.

If the money paid for guarantees to contractors, and, through them to the bonding companies, should be put into the actual road work in the form of careful testing and inspection the yield from the investment would on the whole be much greater and far more satisfying. Why be content with the five-year guarantee of a pavement on a street where that type of pavement should last twenty-five years; and on heavy traffic roads and streets why force the contractor into the position of a gambler. Is it reasonable that he will be able to make any better guess than the engineer on the probable life of the pavement that the engineer has himself designed, the construction of which he has supervised and the materials for which he has or should have tested and approved? No one takes a business risk these days without a sufficient premium, and the overhead costs and profit expected from such risks is easily 100 per cent. That is the figure for fire insurance when the totals of losses paid is one-half the amount of the gross premium receipts.

Now it sometimes happens that good construction of some type costs no more than the poor constructions that are permitted where there is not sufficient inspection and testing and no one in consultation who is possessed of the special knowledge required to differentiate. This will even happen where the testing is well organized if the directing force is not what it should be. Testing alone is not sufficient. Many can make the bare tests more or less well who do not recognize the significance of the results after they have got them, and who do not know how to go about correcting the defects indicated by the tests. To be of certain value, the scientific work should begin with a study of the sources of supply of the materials, the costs of securing them, their proper selection and combination regulated by field tests, and the final laboratory analyzing and testing of the finished product as a check upon the practical work that has been done in the field. Only in this way can a road department be certain that it is not squandering the public funds in under-grade work.

DETERMINING THE TRAFFIC AREA OF IMPROVED ROADS.

Contributed by Chas. R. Thomas, Assistant Engineer, Construction Service Co., New York.

Tributary to each road is an area of farm land which originates market produce and for which supplies must be hauled from market. This area which produces traffic is frequently called a traffic area. These traffic areas adjoin each road that radiates from a market center. The shape of the traffic area depends upon whether the road is a thoroughfare for through traffic between town as well as a drain for the adjacent country. If the road simply leads from the country to the market center the area from which the road attracts traffic generally assumes the shape of two triangles the market road forming a common side. The distance to the right or left of the road from which traffic is attracted may be ascertained roughly by determining the ratio of the diminution of the cost of travel or the ratio of improvement of the long route as compared with the more direct route. If the cost of travel over the main road plus the cost over the cross-road to the starting point equals the cost by a direct line, the starting point is on the margin of the traffic area.

Between towns the traffic area assumes a diamond shape, the through road forming the long diagonal, the traffic being divided in two parts, one of which goes to each town. The portion of the road nearest town receives much greater use than the more distant portion having to sustain a traffic incidental to the town as well as from the natural concentration of traffic as the mouth of the funnel is approached. The average haul for farm produce is frequently estimated from the maximum haul and may be taken as two-thirds of the average maximum haul. The average haul is assumed to be the radius of the circle whose area is the maximum haul. The increase of traffic on the road due to the building up of hamlets may be estimated, the traffic being assumed to vary as the square of the number of hamlets. Visits and trips for trade are more frequent as distance is decreased, the volume of traffic being at least inversely as the distance. The total volume of traffic reaching a market center is, however, but little affected.

UNIT PRICES FOR ROAD WORK IN 1916 IN MINNESOTA.

The following table from the recently issued report of the State Highway Commission of Minnesota shows the unit prices for clearing and grubbing, grading and drainage and blade grader work in connection with the State aid road construction in various counties in 1916:

	Clearing and grubbing.		Grading and drainage.		Blade grader work.	
Counties.	Miles.	Av. rate.	Miles.	Av. rate.	Miles.	Av. rate.
Aitkin	57.00	$ 17.50	[illegible]	$1,462.48	.75	[illegible]
Anoka	12.30	27.44	17.80	698.65	2.90	135.62
Becker	21.00	46.38	15.70	1,272.61	5.50	[illegible]
Beltrami	198.11	24.41	19.15	957.96	7.61	206.23
Benton	2.00	30.00	3.00	1,201.29	13.00	185.54
Big Stone	.10	18.00	6.50	853.21	19.80	[illegible]
Blue Earth	1.00	55.00	22.03	871.17	3.50	[illegible]
Brown	.50	215.20	22.35	729.02	.....	.....
Carlton	51.60	35.45	10.25	1,506.67	4.85	323.83
Carver	2.20	104.54	10.20	151.86	.....	.....
Cass	283.85	24.60	71.00	1,558.21	1.00	[illegible]
Chippewa	.....	.....	11.85	1,082.08	8.35	[illegible]
Chisago	[illegible]	[illegible]	6.28	828.91	.61	438.69
Clay	.....	.....	17.30	1,632.19	10.00	364.00
Clearwater	78.06	28.17	15.20	1,347.25	8.40	151.72
Cook	19.40	76.70	5.47	1,467.35	1.89	764.73
Cottonwood	.....	.....	16.50	875.08	16.50	150.00
Crow Wing	46.00	63.37	14.90	1,078.10	19.15	195.65
Dakota	1.80	122.22	10.40	1,805.07	11.90	175.26
Dodge	2.60	151.61	16.50	532.62	15.70	108.26
Douglas	3.20	40.00	14.82	968.39	2.40	136.66
Faribault	2.15	61.39	18.80	1,008.67	.....	.....
Fillmore	.....	.....	12.80	1,314.85	16.50	286.06
Freeborn	7.25	71.58	4.70	1,221.28	3.90	551.28
Goodhue	20.30	50.14	7.40	1,283.15	16.20	137.62
Grant	.....	.....	4.25	1,119.53	2.60	261.54
Hennepin	.....	.....	[illegible]	1,054.52	3.00	303.26
Houston	23.31	56.19	7.40	2,203.06	1.40	535.71
Hubbard	62.50	20.31	15.10	857.54	7.12	170.09
Isanti	8.50	45.61	37.05	323.21		.....
Itasca	194.00	[illegible]	21.50	1,129.72	16.00	177.06
Jackson	10.50	28.18	19.22	1,081.85	5.84	346.45
Kanabee	27.60	46.47	4.70	2,305.23	12.00	158.29
Kandiyohi	5.00	[illegible]	24.60	791.45	8.41	120.90
Kittson	8.25	13.62	15.70	713.05	1.60	190.62
Koochiching	78.07	.....	3.50	740.27	4.00	101.78
Lac Qui Parle	.35	[illegible]	18.10	1,217.39	1.55	330.08
Lake	10.00	60.00	6.50	415.88	12.00	165.28
Le Sueur	.....	.....	11.02	1,255.91	7.10	213.38
Lincoln	.....	.....	18.75	586.73	2.30	156.04
Lyon	.....	.....	19.00	1,560.53	9.50	107.36
McLeod	.....	.....	22.70	996.28	.....	.....
Mahnomen	13.25	[illegible]	[illegible]	1,646.43	.38	364.73
Marshall	9.00	37.55	28.50	685.33	6.00	[illegible]
Martin	2.10	[illegible]	[illegible]	897.29	13.75	111.51
Meeker	.....	.....	5.00	1,540.63	12.50	.....
Mille Lacs	15.00	[illegible]	7.60	917.88	[illegible]	[illegible]
Morrison	130.10	[illegible]	8.00	[illegible]	20.20	[illegible]
Mower	.....	.....	21.25	698.68	1.90	[illegible]
Murray	22.00	9.95	46.50	340.69	61.50	46.62
Nicollet	1.40	[illegible]	11.87	800.73	.18	321.23
Nobles	.....	.....	5.02	1,623.70	12.78	208.34
Norman	.....	.....	7.25	899.86	5.00	[illegible]
Olmsted	1.00	[illegible]	9.25	1,136.32	22.70	[illegible]
Ottertail	4.00	50.00	30.00	701.10	7.87	[illegible]
Pennington	8.00	[illegible]	7.00	840.00		
Pine	62.00	53.71	39.20	1,496.25	1.00	[illegible]
Pipestone	.....	.....	20.50	592.76		
Polk	5.00	[illegible]	31.25	684.55	[illegible]	[illegible]
Pope	.....	.....	10.24	1,645.57	[illegible]	[illegible]
Ramsey			21.33	1,554.16		
Red Lake	[illegible]	26.10	11.50	1,754.89	[illegible]	[illegible]
Redwood	1.05	60.00	57.50	1,195.71		
Renville	7.25	52.26	18.00	662.33	4.50	164.41
Rice	2.35	104.26	13.10	[illegible]	32.80	165.12
Rock			2.07	[illegible]	3.97	272.26
Roseau	[illegible]	[illegible]	[illegible]	4,153.61	22.07	337.96
St. Louis	[illegible]	[illegible]	[illegible]	1,100.00	40.00	200.00
Scott	8.50	[illegible]	[illegible]	865.19	3.00	
Sherburne	[illegible]	[illegible]	7.10	801.51	15.60	[illegible]
Sibley	[illegible]	40.91	[illegible]	499.90	4.00	[illegible]
Stearns	21.95	39.73	5.30	1,976.16	20.80	
Steele	[illegible]	42.05	11.75	561.78	10.50	266.84
Stevens			14.90	734.60	12.17	197.18
Swift			11.30	1,297.08	2.80	
Todd	[illegible]	52.52	10.00	1,193.80	19.70	187.77
Traverse			1.50	514.50	32.50	365.94
Wabasha			6.79	1,670.86	[illegible]	
Wadena	[illegible]	[illegible]	6.19	1,176.04	[illegible]	
Waseca	[illegible]	58.90	[illegible]	1,042.94	[illegible]	227.83
Washington	[illegible]	46.55	4.40	1,779.34		
Watonwan	.60	25.00	21.00	819.21		
Wilkin			.58	982.58	[illegible]	[illegible]
Winona	28.50	[illegible]	41.00	1,133.17	[illegible]	[illegible]
Wright	[illegible]	[illegible]	15.25	1,593.51		
Yellow Medicine	1.30	91.62	1.98	3,362.59	.70	105.21
Averages	..	$ 44.51	.	$1,073.26	.....	$221.12

EFFECT OF WATER ON CONCRETE.

An experimental investigation is being conducted in the Structural Materials Research Laboratory of Lewis Institute, Chicago, on the effect of water on the strength of concrete. Some results of this investigation are presented by Duff A. Abrams, Professor in charge of the Laboratory, in an article in the April Concrete Highway Magazine, from which the matter following is taken.

The diagram Fig. 1 summarizes the results of compression tests on 6x12-in. concrete cylinders made in mixes ranging from 1 part cement and 9 parts aggregate, to 1 part cement and 2 parts aggregate, by volume. These mixes represent concretes of all qualities from the leanest to the richest which are generally used for any purpose. The aggregate consisted of a mixture of sand and pebbles graded in size from the finest particles up to 1¼ in.; exactly the same grading was used in all cases.

These tests show that the effect of proportional changes in the mixing water is approximately the same for all mixes of concrete; consequently a compositive curve has been drawn to show the average effect. The vertical distances represent the relative strength of concrete, expressed as a percent of the maximum which can be secured from a given amount of cement and the same aggregates. The horizontal distances indicate the relative quantity of water used in the mix, considering the amount which gives the maximum strength as 100 per cent.

The amount of water which gives the maximum strength in concrete produces a mix which is too stiff for most purposes. In plants where such products as building units, drain tile, sewer pipe, etc., are manufactured it is desirable to use a mix even drier than that which gives the maximum strength. The molds can thus be removed within a short time; this would be impossible if a wetter and more plastic mix were used.

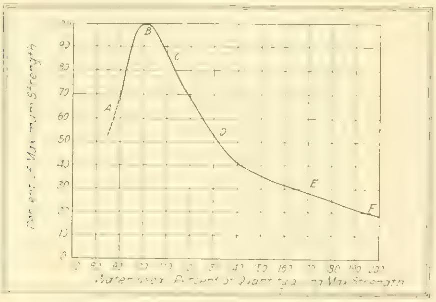


Fig. 1—Diagram Summarizing Compression Tests.

It will be noted that the concrete strength increases rapidly with the quantity of water over the range indicated by A-B on the diagram. With any futher increase in the amount of water there is a rapid falling off in strength, as indicated by the curve BCDEF. With an amount of water about double that required for highest strength, the concrete has only about 20 per cent of the maximum strength.

The exact amount of water corresponding to the maximum strength of concrete will vary with the method of handling and placing the concrete. Any method which involves puddling, tamping, rolling or vibration, or the exertion of pressure in any manner, will have a tendency to increase the strength of the concrete regardless of the amount of water used. However, it is probable that the effect produced by these methods will be more pronounced in the consistencies in the vicinity of the maximum strength.

In constructing concrete roads it is necessary to mix the concrete a little wetter than that giving the maximum strength. The consistency which should be aimed at in constructing roads corresponds to about 105 per cent to 115 per cent of that giving the maximum strength. In other words, a small portion of the strength must be sacrificed in order to secure a workable concrete. The economies resulting from handling the concrete are more important than securing the maximum possible strength for a given amount of cement.

Many contractors in constructing concrete roads insist on using quantities of water varying between 130 per cent and 200 per cent of that corresponding to highest strength. The effect of this practice on the strength of the concrete is indicated by the region D-F on the diagram. It is seen that in this case the strength is being reduced to about 50 per cent or 25 per cent of what should be obtained by a proper consistency. It must be apparent that the wearing quality of a road constructed in this way is much inferior to that of a road made from concrete mixed to a proper consistency.

In building construction it is not uncommon to find concrete mixed with a quantity of water even greater than any used in these tests.

Few engineers or contractors realize the disastrous effects which are certain to accompany the use of too much mixing water. We frequently hear the following reasoning:

1. The excess water does no harm because it runs off and evaporates.
2. While very wet concrete is weak at early ages it gains in strength more rapidly than the drier mixes.
3. The rich mixes used in road construction are less affected by excess water.

The experimental work carried out in this laboratory and elsewhere show that none of these conclusions is correct. The use of excess water produces a concrete which is inferior for all mixes and at all ages. The tests also show that the excess water does not run off until consistencies are reached which correspond to those indicated in the region E-F and beyond. This is indicated by the flattening of the curve which shows that the addition of water beyond that indicated by F has little effect. At this point a degree of "sloppiness" is reached which gives only about 25 per cent of the available strength.

The following questions are often asked:

1. What is the proper consistency for concrete road work?
2. How is this consistency to be determined?

These questions may both be answered in a nutshell by saying that for road construction the concrete should contain the smallest quantity of water which will produce a workable mix. It is evident that there may be a difference of opinion as to what constitutes a workable mix, but the diagram shows that any reduction in the quantity of water within the range which should be aimed at in concrete road construction is accompanied by a rapid increase in the strength of the concrete.

The proper quantity of water will vary with the quantity of cement and the size and grading of the aggregate, and to a less degree on the nature of the aggregate. The water required for a sand and crushed stone aggregate is not appreciably different from that required of a sand and pebble mixture, providing the grading of the aggregates is similar. In case of very soft or porous aggregates (which, however, should not be used in road construction) a somewhat greater quantity of water will be necessary.

The quantity of water required will depend to a minor degree on such factors as the type of concrete mixer, method of placing the concrete, method of finishing, temperature, etc.

There is no direct criterion for determining in advance the best quantity of water for concrete being placed on a road. The concrete should be mixed so that only a small quantity of free water will appear on the surface

TABLE I.

Mix		Approximate mix as usually expressed			Water required. (Gallons per sack of cement.)	
			Aggregate			
Cement	Volume of aggregate after mixing.	Cement	Fine.	Coarse.	Minimum.	Maximum
1	5	1	2	4	6	6½
1	4½	1	2	3	5¾	6¼
1	4	1	1½	3	5½	6
1	3	1	1¼	2½	5	5½

after leveling and striking off. This gives concrete of a jelly-like consistency.

The principal difficulty in the way of attempting to determine in advance the proper quantity of water for use in concrete roads, is due to the fact that the aggregates are generally damp and the degree of dampness is not uniform, but varies from time to time. In the case of concrete made of sand and pebbles or sand and crushed stone, well graded in sizes up to 1½ in., Table I indicates about the quantity of water which should be used for mixes which are commonly employed in concrete roads.

This assumes, of course, that the aggregates are in a room-dry condition. Any moisture contained in the aggregates on the work must be taken into account. Most sand piled along the roadside will contain from 3 to 10 per cent by weight of water. In the table the water content is given in terms of gallons per sack of cement. It is not expected that these values will be of general application since the quantity of water will vary with the size and grading of the aggregate, but they may be found useful in suggesting the limits which should be kept in mind in concrete road construction.

PORTABLE ROCK CRUSHING OUTFIT FOR UTILIZING OLD MACADAM.

The use of a portable rock crushing plant enabled a Chicago contractor to make a marked saving in the cost of the crushed stone for the concrete base of the new pavement. This contractor, the Calumet Coal & Teaming Co., 9022 Commercial Ave., South Chicago, has contracts for about 22 miles of new street paving, all of which is located in the southern part of Chicago. A part of this work was the construction of a new pavement on Stony Island Ave., from 56th to 67th Sts., bordering Jackson Park. The old pavement was macadam with limestone curbs and crossings. This was torn up with a scarifier and all material contained in pavement, crossings and curbs was loaded into dump wagons with a ¼-yd. Thew shovel and hauled to the crushing plant.

Portable Rock-Crushing Outfit Producing Concrete Aggregate from Old Pavement.

The crusher was located in a large vacant area at 59th St. and Stony Island Ave., which provided a short haul for most of the material. The plant consisted of an Austin No. 3 gyratory crusher mounted on trucks and equipped with elevator, revolving screen and portable bin, the crusher being belt driven by a road roller. The crusher was placed in a pit about 4 ft. below ground level. This permitted bridging it over with only slight inclines so that material could be discharged from the dump wagons directly into the crusher. The accompanying photograph shows the general arrangement of the plant and illustrates a load of material being discharged into crusher and a motor truck loading with crushed stone from the portable bin.

In this work, aggregating a little more than a mile of street, there was reclaimed over 3,000 yd. of crushed stone from the waste at a total cost of 60 ct. a cubic yard. All dirt and waste were screened from the stone in this operation, producing a clean crushed stone product. The present price of crushed stone in this part of Chicago is about $1.75 a cubic yard. The saving effected more than paid for the entire cost of the crushing plant.

When this job was completed the crushing plant was moved to 74th St. and Constance Ave. to crush a large pile of limestone rock removed from the 73d St. water tunnel. There is no waste in this product, all of the crushed stone and screenings being used either for pavement construction or sold for other improvements in the vicinity and the cost per yard undoubtedly will be considerably less than on the Stony Island job.

CONTRACT PRICES ON ILLINOIS STATE AID ROAD WORK IN 1915 AND IN 1916.

The following tabulation compiled from the report of the State Highway Department of Illinois for the years 1915-1916 shows the contract prices for various concrete and brick paved roads in the years mentioned. The total price per mile includes the cost of the cement, shoulders in the case of the 10-ft. widths, grading and structures. The figures given are the averages for a large amount of construction:

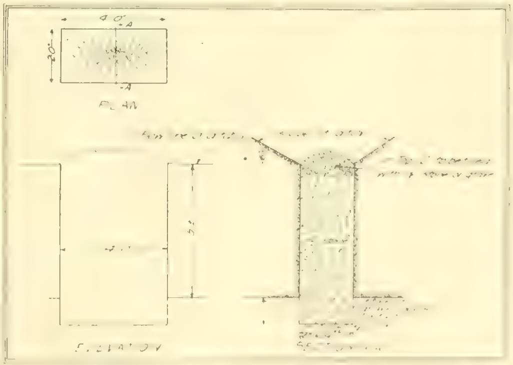
	Jan. 1, 1914-Dec. 31, 1915.	Jan. 1, 1916-Dec. 31, 1916.
10-ft. concrete roads:		
Total price per mile	$10,199.00	$11,440.00
Pavement proper, per mile	7,212.00	7,900.00
Pavement proper, per sq. yd.	1.23	1.35
Macadam shoulders, per mile	1,907.00	2,150.00
Macadam shoulders, per sq. yd.	.41	.46
15-ft. concrete roads:		
Total price per mile	11,768.00	16,350.00
Pavement proper, per mile	9,791.00	12,000.00
Pavement proper, per sq. yd.	1,11	1.36
18-ft. concrete roads:		
Total price per mile	14,507.00	15,750.00
Pavement proper, per mile	12,084.00	12,400.00
Pavement proper, per sq. yd.	1.14	1.17
10-ft. brick roads:		
Total price per mile	13,456.00	12,500.00
Pavement proper, per mile	11,285.00	10,800.00
Pavement proper, per sq. yd.	1.92	1.85
18-ft. brick roads:		
Total price per mile	24,475.00	21,300.00
Pavement proper, per mile	19,776.00	19,600.00
Pavement proper, per sq. yd.	1.87	1.85

CATCH BASINS SOLVE ROAD DRAINAGE PROBLEMS.

Surface drainage on a section of State aid road constructed last year in Winnebago County, near Rockford, Ill., is taken care of by means of catch basins. When the surveys were made it was found that the entire 2 miles of road was practically level. The maximum variation in elevation was approximately 1 ft. Surface drainage by open ditches was impracticable, and the construction of a sewer would have been very expensive.

An investigation of the subsoil revealed coarse gravel at an average depth of 7 ft. below the general ground surface. The covering over the gravel strata was more or less impervious and retarded the seepage of surface water.

In order to utilize the gravel subsoil as an aid in drainage it was therefore necessary to effect openings through the semi-impervious top soil. This was done by constructing stone wells or catch basins as outlined in the attached sketch. These catch basins were placed about 400 ft. apart and on both sides of the road. The ditches, which were an average of 2 ft. in depth, were made to drain into these wells or catch basins.



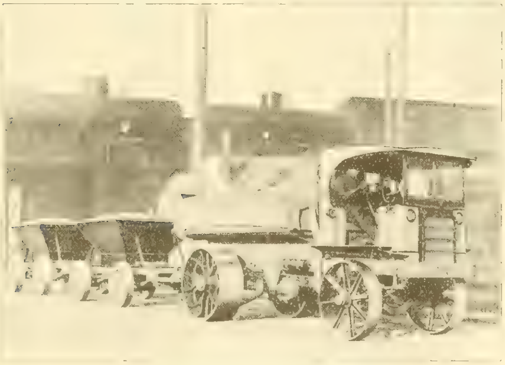
Plan Section and Elevation of Catch Basin.

As a precaution against blocking the wells with leaves and ice, the stone was rounded up 6 in. above the flow line of the ditch. For ease of maintenance 1½-in. stone was used in the top 1 ft. of the well. This smaller stone acts as a filler and makes it possible to maintain the well in good condition by clearing out the top part of the stone.

This method of drainage has proved very satisfactory and economical. The catch basins built last year cost $4 each. A. R. Carter, Rockford, Ill., is County Superintendent for Highways. H. B. Bushnell, Aurora, Ill., is Division Engineer in charge of State aid work.

NEW GARFORD TRUCK FOR ROAD CONSTRUCTION AND MAINTENANCE PURPOSES.

A new truck model designed especially for road construction and maintenance purposes has been brought out by the Garford Motor Truck Co., Lima, O. This new model, known as the Garford Road Builder, has a body capacity of 5 cu. yd. The body is flanged at the top and at the corners, and is reinforced with extra heavy gusset plates. It is supported on two 4-in. I-beams running lengthwise and connected by five 4-in. I-beam cross sills. The body is 10 ft. long, 24 in. deep and is 6 ft. wide at the front and 6½ ft. at the rear end.



The Garford Road Builder.

An important feature of the body construction is the regulation of the tail-gate opening for the spreading of material to any desired thickness. The hoist is operated by hydraulic pressure and an automatic cut-out is provided at the extreme dumping angle. The entire mechanism is controlled from the driver's seat and is so simple that any truck driver can quickly become accustomed to it.

The front wheels are equipped with wide center rims and the rear wheels with cleats of the herring bone type, all of which may be easily and quickly detached.

The short wheel base (128 in.) makes turning possible on very narrow roads and cramped quarters. At the same time a short frame length reduces weight and adds sturdiness to the construction.

COST OF MINNESOTA STATE RURAL HIGHWAYS.

Some of most substantial road work accomplished in the State of Minnesota has been done under the State Rural Highway Law of 1911. Under this law County Boards were permitted to establish state rural highways on petition of six or more landowners and to let contracts and issue bonds to finance the work, charging one-half against the State, one-fourth against the county and one-fourth against the property benefited. The law was repealed in 1915. During the first two years the law was in operation, practically nothing was done, but during the past two years very satisfactory results were obtained by those counties which availed themselves of the law by starting proceedings before its repeal. In all, 50 State rural highways were placed under construction. These highways are now about completed. The following tabulation from the last biennial report of the State Highway Commission, issued March 1, gives some details of the work:

County.	Length. Miles.	Class.	Cost per mile.
Aitkin	20.1	Surfaced	$ 2,805*
Aitkin	19.0	Surfaced	2,953†
Aitkin	64.0	Surfaced	3,326
Beltrami	5.5	Surfaced	2,713†
Beltrami	12.73	Surfaced	1,862
Beltrami	6.5	Surfaced	2,436§
Beltrami and Kooch.	45.11	Surfaced	2,399†
Beltrami	33.5	Surfaced	3,623
Beltrami	34.81	Surfaced	4,283†
Blue Earth	11.3	Gravel	1,926*
Brown	29.	Gravel	1,979†
Carlton	28.02	Gravel	3,675
Cass	22.59	Earth	2,781‡
Cass	71.7	Surfaced	3,003‡
Cass	45.65	Surfaced	1,629‡
Cass and Hubbard	29.50	Surfaced	2,933
Cass	29.25	Surfaced	2,497†
Hennepin	2.99	Concrete	17,272*
Hubbard	9.	Surfaced	599
Hubbard	46.87	Surfaced	1,593
Hubbard	10.85	Surfaced	1,606*
Koochiching	23.	Earth	1,396†
Koochiching	75.1	Earth	2,074†
Koochiching	21.7	Earth	1,025†
Koochiching	52.77	Earth	2,196†
Lincoln	20.4	Gravel	2,038*
Lyon	24.5	Gravel	1,869†
Nicollet	27.5	Gravel	2,014
Nicollet	12.5	Gravel	2,445
Pennington	21.	Gravel	2,259*
Pine	30.	Earth	2,127†
Redwood	5.75	Gravel	1,338*
Redwood	6	Gravel	1,913‡
Redwood	22.93	Gravel	2,464‡
Redwood	8.	Gravel	3,620‡
Redwood	18.5	Gravel	3,057‡
St. Louis	32.5	Gravel	4,556*
Winona	6.86	Concrete	8,290*
Winona	4.35	Concrete	7,038*
Winona	4.60	Concrete	7,287*
Winona	27.05	Brick Macadam	6,543‡
Winona	20.85	Macadam	5,311†
Winona	7.7	Macadam	6,576‡
Winona	7.02	Gravel	4,311‡
Winona	4.4	Gravel	4,417‡
Winona	4.95	Gravel	4,007
Winona	6.	Gravel	4,353‡
Winona	10.5	Gravel Macadam	4,873
Yellow Medicine	18.5	Gravel	2,946†
Yellow Medicine	31.	Gravel	2,328*

Total number of miles for 50 S. R. H.'s. . . . 1,133.90

Total cost of 50 S. R. H.'s. . . . $3,254,032.50

Average cost per mile. . . . $ 2,869.71

*Final cost. †Contract price. §Not final. ‡Estimated

PERSONALS.

W. G. Thompson, Steelton, Pa., has been appointed assistant highway engineer of the New Jersey State Highway Department.

Z. E. Stevens, for the past four years city and county engineer at Laramie, Wyo., has been appointed state highway engineer of Wyoming

Edward Flad, consulting engineer, St. Louis, Mo., has been appointed engineer member of the Public Service Commission of the State of Missouri.

Charles S. Sincerbeaux and G. Roland Moore have entered into a partnership and will engage in an engineering practice. Offices will be maintained at Asbury Park, N. J., and Princeton, N. J.

Victor Hansen has been appointed Chief Carpenter of the Iowa and Dakota Division of the Chicago, Milwaukee & St. Paul Ry., with office at Mason City, Iowa, vice C. J. Hansen, who has left the railway company's service.

Chas. C. Smith has been appointed city engineer of San Angelo, Texas, succeeding Mr. H. M. Garden, resigned. San Angelo is under the Commission-Manager form of government, having adopted the charter about 2 years ago.

The Engineers' Club of Columbus, O., was reorganized on April 20th with an active membership of 150. Through the co-operation of the Columbus Chamber of Commerce, the club will occupy spacious quarters in the Chamber of Commerce Building. The following officers were elected for the ensuing year: President, E. G. Bradbury, First Vice-President, C. T. Morris; Second Vice-President, J. J. Morgan; Treasurer, F. H. Eno; Board of Control, A. H. Hinkle, Philip Burgess, Thomas H. Brannan, Dudley T. Fisher; Librarian, F. L. Purdy; Secretary, M. Z. Bair.

INDUSTRIAL NOTES.

The American Steel Exports Co., Woolworth Bldg., New York, announces the appointment of Charles S. Vought as assistant general manager of sales.

The Duplex Manufacturing & Foundry Co. has removed its main offices to Elyria, O. The active management of his company has been transferred to A. F. Ehrbar.

The Archer Iron Works, 2665 W. 39th Pl., Chicago, has just completed an enlargement of its factory building, increasing the floor space by 50 per cent. This improvement was made necessary by the demands for the concrete mixers manufactured by the company.

The Road-Maker, formerly at Moline, Ill., is now located in Chicago, and will hereafter be published by the International Trade Press at 515 Monadnock Block. Joe L. Long, its founder, still holds his interest in The Road-Maker, and will continue to direct its policies as editor and manager. H. E. Hopkins is retained as managing editor.

Robert W. Hunt, President of Robert W. Hunt & Co., engineers, specializing in inspections, tests and consultations, Chicago, has offered the services of his company to the War Department on terms which will mean their being rendered to the government at their actual cost. This was done as a patriotic duty because it is believed that with the large and efficient organization of the company and its peculiar character it can be of service to the country in a particularly practical manner, and at a cost to the country of much less than equivalent services could be otherwise obtained. The Robert W. Hunt & Co. organization has been in existence nearly 30 years, and has grown in size and efficiency based upon its actual operations. It now embraces about 700 people, consisting of experienced civil, mechanical, metallurgical, chemical and mining engineers, supported by a corps of subordinates, most of whom are also men of technical and practical education, and the others selected on account of their practical experience in the several lines of duty to which they are assigned.

eight million pounds of water. Picture to yourself a pint of liquid chlorine and a reservoir of water 8 ft. deep, 20 ft. wide and 400 ft. long, containing 4,000,000 lb. of water. Pour this pint of chlorine into this great tank of water and mix it up. You will be unable to see, taste or smell the chlorine thus diluted, but every typhoid germ will forthwith "curl up and die." Talk about homeopathic dosing! The ghost of Dr. Hahnemann must turn green with envy every time the valve of a chlorinator opens to vent its tiny droppings. Think of it! One drop of chlorine in two barrels of water puts Mr. Microbe permanently to sleep.

Every year 300,000 Americans are incapacitated by typhoid and 20,000 of them die. Bring these figures home to yourself. Imagine every citizen of Seattle, or of Indianapolis, being compelled to suffer for weeks every year from this terrible disease; and then, in your imagination, follow 20,000 hearses to the grave. What you thus imagine is the numerical equivalent of what actually happens every year. And it is a preventable happening, preventable at a cost so low that nothing but gross ignorance accounts for our failure to act. Resolve to do your part to eliminate this ignorance and its consequent suffering.

PREVENTABLE CROP FAILURES AND THE OPPORTUNITY FOR CIVIL ENGINEERS.

Government crop reports have indicated an abnormally small yield of winter wheat, and the main cause has been lack of rain. In many cases the soil was so dry that the wind uncovered the germinating seeds and thus destroyed the crop. In other cases there was lack of snow, and in wet soils the seed was frozen. In both cases the losses were largely avoidable. Irrigation and tile drainage would not only have insured normal crops but supernormal yields.

A wet soil is a cold soil, for water is many fold as good a heat conductor as air. A wet soil not only retards the growth of plants but often prevents any growth. A dry soil is equally barren. There must be a happy medium—a moist soil—to secure the best results. Now a moist soil may be had occasionally by chance, but can be had always by design. Under-drainage for dense soils and irrigation for all soils furnish the twin methods whereby chance as to soil moisture may be eliminated.

Hydraulic engineers can solve this important problem in farming, and they know it. Yet there most of them halt, waiting for farmers to call upon them for their services. But the farmer has a habit of not calling. All the publicity forces of our great Department of Agriculture fail to get much beneath the tympanum of the average farmer. He waits to be gripped by the hand and talked into doing what he should do. He waits to be shown how to secure the needed capital on long-time terms. Let these two things be done and we shall see few crop failures. Farming will cease to be a gamble.

Now it happens that important steps are being taken to secure for farmers the capital needed for improvements, such as drains and irrigating pumps and pipe. Hence the present seems an opportune time for civil engineers to go among farmers to secure the work of designing and building drainage and irrigation systems. Is it a mere dream to suppose that an engineer can thus secure profitable employment? Listen. One firm, Layne & Bowler, of Houston, Texas, and Los Angeles, has installed 400 deep well turbine pumps in one county of Arkansas during the last four years—all for farm irrigation. That firm of engineers and manufacturers has demonstrated that it pays to "go out among 'em."

We suggest to engineers who contemplate specializing in "land betterment engineering" that a great deal of valuable information is securable without cost. The U. S. Department of Agriculture and the various State Agricultural Experiment Stations have issued many bulletins on irrigation and drainage. The catalogs and booklets of manufacturers of pumps, pipe, trench diggers, overhead irrigation systems, etc., contain a wealth of useful material.

Agencies for manufacturers could be secured by those who plan not merely the designing but the furnishing of complete installations. Doubtless the largest incomes will be secured by those who promote as well as design irrigation and drainage plants. There is not a state in the Union where both irrigation and drainage is not economically needed to a degree that few have realized.

THE ECONOMY OF POWER TAMPING.

One man operating a small power tamping machine will compact as much tough earth in a trench as ten or more men. Thus, in tough Milwaukee clay it requires 3 men tamping to every man shoveling dirt into a trench, where thorough consolidation is desired; and such a gang of 4 men will handle about 2 cu. yds. of backfill (trench measure) per hour. With wages at 30 ct. per man per hour, the cost is 60 ct. per cu. yd. for back-filling and tamping, of which 45 ct. is for the tamping alone. This, of course, is for tough clay thoroughly compacted.

Contrast this cost with tamping with a 3-H.P. gasoline machine, operated by a skilled man. The wages are 50 ct. an hour, and the machine uses about half a gallon of gasoline per hour. Hence wages, gasoline and oil cost about 65 ct. an hour. Working on tough clay the machine thoroughly compacts 7 cu. yd. per hour, at a labor and fuel cost of less than 10 ct. per cu. yd. The cost of interest, depreciation and repairs depends so largely upon the number of days that the machine is kept busy each year that no average figures can be given. But, as the machine is comparatively low priced, it is safe to say that the combined interest, depreciation and repairs would seldom exceed $400 a year, or about the wages of a gang of 10 men for 14 days, which is an amount of labor speedily saved by the use of a power tamper.

We have said nothing about the superior quality of tamping done with a machine, and it needs no argument on this score. A tamper weighing 150 lb., whose head covers 9x12 in., striking 40 blows a minute, so evidently out-classes what a laborer can do that argument is unnecessary. The ram of the power tamper has a drop of more than 2 ft., so that the energy of its blow is more than 300-ft. lb. A laborer using a 15-lb. tamper, which he raises 1 ft., delivers only 15-ft. lb. of tamping energy per blow, and about 20 blows per minute. Hence, a laborer delivers 300-ft. lb. of tamping energy per minute as compared with 12,000-ft. lb. per minute delivered by the machine.

Some of those who have used a tamping machine rate it as equivalent to 18 men, and doubtless it is, if the men are compelled to compact the earth as thoroughly as with a power tamper.

A power tamper is self-propelled, moving slowly (6 ft. per min.) back and forth along the trench. It's ram travels laterally back and forth across the trench, thus beating down a 6 or 8-in. layer of loose earth to a thickness of 4 in.

We have spoken only of the direct cost of thoroughly tamping a backfill, but what of the indirect cost of not tamping thoroughly? Many a ruined pavement bears witness to that sort of cost. In other cases pavements are not relaid for months after a trench is cut through them, to give the earth time to settle—a barbaric method to be sure, and one that accounts for measureless wear and tear on trucks and pleasure vehicles. Power tamping now makes it inexcusable to leave cuts in pavements unpaved. Equally without excuse is the pavement that has cracked over a trench.

EDITORIAL COMMENT.

Unite! Some sort of united effort should be initiated by the two waterworks associations. So long as certain members feel that the individuality of neither of the societies should be given up, let a plan of "federating" them be worked out. A few years ago the great American Society of Civil Engineers, proud of its history and perhaps slightly snobbish, refused to join with the other great national engineering societies even to the extent of sharing quarters and merging libraries. Recently the Am. Soc. C. E. wisely came a right about face, and has "federated" with other societies to that extent. Let not the progressive members of the American Water Works and of the New England Water Works associations be disheartened because past efforts toward a union have been seemingly futile. The reasons for a union so greatly overwhelm those for entirely separate existence that a federation will undoubtedly occur.

Most farmers regard themselves as fortunate if they average 200 bu. of potatoes per acre. But they are mere pikers. Sweet Brothers, of Carbondale, Col., average 500 bu. on each of their 125 irrigated acres, with 14,000 hills to the acre! They have become celebrated as breeders of potatoes of uniform size and quality. If they could market their whole crop at the prevailing $4 price, all their 125 acres would yield them would be $250,000 this season! Does it pay to irrigate? Does it pay to do anything scientifically?

We have been asked to name some place east of the Mississippi where city water is used to irrigate truck gardens. The Kentucky State University is such a place. Water from the city mains is applied to several acres by an overhead sprinkling system. Not only every university but every high school might well pattern after this example, and thus spread the knowledge that city water systems are useful as irrigating plants.

Common labor will be scarcer than ever this season. Consequently it will be more economic than ever to do work by machinery rather than by hand. Trench digging, back-filling and tamping are operations that are still done by hand, for the most part, although excellent machines are made for each of these three operations. The newest of the three is the power tamper for trench work. Some specifications call for the back-filling of trenches in clay with sand and gravel, because the clay can not be satisfactorily consolidated by hand tamping. The price of a power tamper is speedily saved where this is the case, and in every case where much tamping is required it will pay to investigate what can be saved by the use of one of these little machines.

In 14 years the U. S. Reclamation Service has built 9,600 miles of canals and ditches and 25 miles of tunnels, involving the excavation of 130,000,000 cu. yd. During the same time 12,300,000 cu. yd. have been placed in earth and masonry dams. Extensive as this development has been, it barely marks the beginning of irrigation work in the west.

An official of one of Philadelphia's greatest corporations has been urging the employes to plant gardens. In Japan one acre of ground supports a family of five persons, according to "Girard," who adds: "So if our people go at this small garden game not as a fad, but as a provider for the dinner table, a roast potato will cease to bump elbows on the price card with terrapin and champagne." To which permit us to add—provided the water spigot is judicially made to supplement the clouds. A water supply that soars through the heavens may be cheap but it travels without schedule.

The president of Pennsylvania State College, Dr. Edwin E. Sparks, says: "We are urging medical students and engineers to complete their [college] preparation in order to render skilled service. Let us not in this time of excitement lose our heads and do damage to the future by thinking only of the present." Dr. Sparks voices the judgment of many educators who regard it as a huge mistake to encourage engineering students to join the army before they have completed their four years of engineering training.

LOGIC FOR ENGINEERS.

V. The Categories of Energy. (Mass).

By Halbert P. Gillette.

[The previous articles of this series are: I—Energy and Cause-Effect, Jan. 31; II—The Senses and Feelings, Feb. 28; III—The Categories of Energy (Number), Mar. 28; IV—The Categories of Energy (Space and Time), Apr. 11.]

Weight.—Both weight and mass indicate a quantity of matter. Although the distinction between weight and mass is presumably known to all trained engineers, there are relatively few who do not find themselves puzzled if they attempt to picture the difference mentally. It is one thing to say that weight is the product of mass into the acceleration of gravity, and it is quite another thing to translate this equation into a definite picture. Indeed I question whether many engineers have ever seriously attempted to form a mental picture of the distinction between weight and mass. Certainly no picture can be formed until a picturable theory of gravitation in general is formed.

No mental picture at all exists when gravitation is asserted to be "an inherent force of attraction." Such an expression, when critically examined, is found to be merely a group of symbols which individually may symbolize something but collectively symbolize nothing definite. Newton, Locke, and other early philosophers, frankly confessed inability to picture any force as acting without contact of material bodies. But it has become the habit in recent years to attribute such inability to ignorance. Newton's insistence upon an ethereal medium for the transmission of gravitation is regarded by John Stuart Mill (Logic, Book V, Chap. 3), as evidence of poor reasoning power. I confess that Newton's argument seems to me more sound than Mill's criticism of it. Newton said:

> It is inconceivable that inanimate brute matter should, without the mediation of something else, which is not material, operate upon and affect other matter without mutual contact.

Accordingly Newton pictured to himself the existence of an ether that filled all space and was the medium through which gravitational force was transmitted.

> That gravity should be innate, inherent and essential to matter, so that one body may act on another at a distance, through a vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man, who in philosophical matters has a competent faculty of thinking, can ever fall into.

Mill puts these quoted paragraphs among "fallacies of simple inspection," and ridicules Newton thus:

> This passage should be hung up in the cabinet of every cultivator of science whoever attempted to pronounce a fact impossible because it appears to him inconceivable.

With the first paragraph that I have quoted from Newton I agree completely. It is impossible for me to form a mental picture (that is, to conceive) energy acting across "pure space." If I grant that it does so act, then I do so in pure ignorance of how it acts; and when I do that, I admit at once that I have no conception, no picture, of its action.

The philosophical mind, while recognizing that there are limitations to human conception, nevertheless refuses to submit to a limitation if there is any escape from it. Newton conceived that an explanation of gravitational action was to be had if an ether exists. As between Newton, who refused to admit that he had reached an ultimate and inexplicable phenomenon, and Mill who asserted that the ultimate had been attained when matter was said to yield to force acting through "pure space," I think most scientific men will choose to travel with Newton.

Newton did not offer a hypothesis of the action of gravitation through space, further than to assume the existence of an all-pervading ether. But in 1818 Le Sage advanced a gravitational hypothesis that has the great merit not only of giving a clear picture of gravitation but of showing why it varies as the product of the masses and inversely as the square of the distance between them.

Le Sage's Theory of Gravitation.—Le Sage supposed the universe to be thronged with "ultra-mundane corpuscles" moving with great velocity. He assumed that they pass through the largest masses without being absorbed except to a very small extent, the absorption being proportional to the mass, thus communicating their momentum to the mass. If the corpuscles are uniformly distributed, there is no resulting motion of a mass from the "absorption" of the corpuscles. If, however, there are two masses, A and B, B will shield A from some of the corpuscles moving in the direction BA, and A consequently will not receive as much momentum in this direction as if B were not present. Consequently A will move in the direction AB; and, for a similar reason, B will move toward A because A shields B from corpuscles moving in the direction AB. Granting this hypothesis, which is analogous to the action of light, it is easy to see that the effective impact of corpuscles on A and B varies inversely as the square of the distance A B, and directly as the product of the masses A and B.

It was objected to this theory that heat would be developed by the impact of corpuscles on bodies, but J. J. Thomson pertinently remarks:

> We need not suppose that this energy is converted into heat. * * * It is a very interesting result of recent discoveries that the machinery which Le Sage introduced for the purpose of his theory has a very close analogy with things for we have now direct experimental evidence. We know that small particles moving with very high speeds do exist, that they possess considerable powers of penetrating solids, though not, as far as we know at present, to an extent comparable with that postulated by Le Sage; and we know that the energy lost by them as they pass through a solid is to a very large extent converted into a still more penetrating form of radiation, Rontgen rays.

The evidence in favor of the substantial truth of the Le Sage theory of gravitation is strong enough to warrant its provisional acceptance. Certainly it is more rational to adopt a definite and picturable theory of this sort, even if it does not explain everything, than it is to call gravitation an "inherent force that acts across space," and thus seemingly escape an out and out confession of complete ignorance.

Leibnitz, as far back as 1671, suggested a theory of gravitation which postulated the existence of an ether in motion. But, lacking knowledge of the laws of gravitation as subsequently established by Newton, he failed to give his theory the form that it took under Le Sage.

Weight.—A body supported by the earth gives evidence of a force that thrusts it toward the earth's center. If a body is held in the hand the "muscular sense" gives evidence of this force.

If the weight of a piston in a vertical cylinder is supported by air in the cylinder, the downward force holds the air in compression. In this case we know that the impacts of the molecules of air in the cylinder support the piston, and without change of energy in the compressed air. Does it not seem probable that if a bombardment of the molecules of compressed air serves to support the piston, a bombardment of free corpuscles in the opposite direction (toward the earth's center) may be the cause of the downward pressure of the piston, which downward pressure is called its weight?

Le Sage's theory shows why this corpuscular bombardment manifests itself as a pressure, because of the shadow effect of one mass upon another mass.

Weight, then, is a pressure due to the shadowed bombardment of free corpuscles upon a mass, which is exactly opposed by the elastic reaction of matter.

We need not now concern ourselves with an explanation of the phenomenon of elasticity. But it may be remarked that the elasticity of solids is probably a corpuscular bombardment phenomenon also.

Weight, according to this explanation, varies with the mass (m), and with the shadowed corpuscular bombardment, which latter is measured by the acceleration of gravity (g).

A freely falling body, according to this explanation, should not be spoken of as manifesting weight. It manifests mass and energy; and when it comes to rest it manifests weight.

Weight is sensed by only one of the senses—the sense of touch, or, if preferred, the "sense of muscular pressure." The elastic reaction of the muscles under a pressure causes chemical changes in the nerves of touch, and the changes are sensed. Sensations of pressure gave rise to the conception of "static forces" or pressures, among which is the vertical pressure of a mass which is called its weight.

Mass.—Mass is quantity of matter, but what does "quantity" imply? In the third article of this series it was shown that a quantity is a number of units of the same kind. In matter the ultimate units of the same kind are the bound corpuscles that constitute the atoms. Hence it follows that—

The mass of a body is the number of bound corpuscles that constitute the body.

The mass of a body is independent of its position relative to other bodies.

That species of the sense of touch that is called the "muscular sense" recognizes differences in pressure and therefore crudely detects differences in the mass of bodies by its discernment of differences in weights. The sense of sight may be said to measure a certain part of the "surface energy" of a body, whereas the muscular sense may be said to measure weight which is proportional to mass.

Summary.—The four categories of energy—number, space, time and mass—are not separable causes or effects, but are inseparably present in every cause or effect. Although they are actually inseparable, the mind may direct its attention upon any one of the categories, seemingly excluding the existence of the others. This mental ability arises mainly from the existence of five different senses.

Number and time are sensed by every one of the five senses, but weight is sensed only by the sense of touch. Space is sensed only by touch and sight.

Are spatial relations existent without motion and therefore without time? No, but the motions are rhythmic and so rapidly repeated as not be sensed as motions. Although time is involved in every perception of a spatial relation the time element may be ignored in spatial relations because it is the same for all of them.

If energy, which is mass in motion, is the cause of all sensation, and if reasoning is founded on sensation, how comes it that we are able to reason about geometric lines that are postulated as being without mass? Every visible line actually has mass, and only because of its energy is it visible. The geometrician's dictum that length may exist without breadth is simply pure fiction and unrealizable. Time and mass are both involved in the seeing of a physical line, but the time is a constant and the mass is a multiple of the length; hence the length of a line is a measure of its energy.

It would carry us deeply into a consideration of the various forms of energy and the action of the mind if we were to persue this subject further at this juncture. I trust, therefore, that this brief outline of philosophy of energy and its categories will serve sufficiently well as an introduction to a study of the operations of the mind.

The mind itself is a complex energy-group of nerve-stuff, its interaction with external energies produces those changed forms of the nerve-stuff that we call sense-records and feeling-records. In the next article of this series we shall pass to the subject of the formation of sense-records and the replaying of those records. Thence we shall come to a conception of what constitutes reasoning and wherein it is related to observation and memory.

Leaks in Water Mains, Springfield, Mass.—During 1916 there were 39 leaks in the main pipes of the water works system of Springfield, Mass., an average of 0.17 per mile of main pipe. Of this number 26 were at bad joints, 5 were in hydrant connections, 3 were caused directly by work of parties outside the department, and 2 plugs blew out.

CARBON DIOXIDE AND IRON IN WATER SUPPLIES.

Contributed by C. G. Wigley, Chief Bureau of Engineering, New Jersey Department of Health, and F. N. Daniels.

Carbon dioxide, or carbonic acid gas, is a normal constituent of natural waters. It may be derived from the atmosphere, or may be produced by the decomposition of organic matter, and is found in rain water, surface streams and deep well supplies. It may occur in the form of free CO_2, or it may be combined as a bicarbonate of lime, or magnesia.

On heating water containing the above mentioned carbonates, much of the carbon dioxide gas is released. The amount of this gas usually occurring in surface waters does not make it an objectionable constituent, as it improves the appearance of the water and imparts to it a slight but pleasant taste. It is, however, sometimes objectionable for the reason that it attacks the iron of the water mains and causes a deposit of iron. The theory advanced in reference to this action is that the weak carbonic acid acts upon the exposed or uncoated portions of the mains forming a ferrous salt, which is in turn oxidized by the oxygen normally present in the water to a ferric hydrate.

In the latter chemical change the carbon dioxide is released so that it may again attack the iron and gradually increase the area of iron exposed, so that a cycle is completed and small quantities of the gas may cause serious deposits of ferric hydrate. Ferric hydrate is precipitated as a reddish yellow sediment which readily stains porcelain bath fixtures and white clothing washed in the water. The effect is not generally noticeable unless there is more than 0.5 of a part per million of iron present in the supply. More iron than the amount mentioned may cause a disagreeable and characteristic taste.

Iron may, of course, occur in the water as one of its natural components being held in solution probably in the form of ferrous carbonate which upon exposure to air oxidizes, quickly forming the reddish yellow deposit and causing the water to become turbid.

It is apparent from the foregoing statements that when red water troubles are experienced it is necessary to investigate the source of the iron. Therefore tests may be made to determine whether or not the iron is present in the water as it is taken from its source, such as a deep well. This is the case in many wells in New Jersey, ranging in depth from 100 ft. to 1,200 ft. Here the iron should be removed by treatment at the source by aeration, sedimentation and generally followed by filtration or by precipitation with lime.

If iron is not present in the source of supply in such quantity as to be objectionable the supply should be tested for carbon dioxide, which as pointed out above, will often cause the corrosion of the mains.

In the following portions of this article there are given accounts of two instances in which red water troubles were caused by carbon dioxide being present in the supply, although the sources of this gas were different in the two cases cited. There is also given a description of the methods utilized to improve the quality of the water supplies.

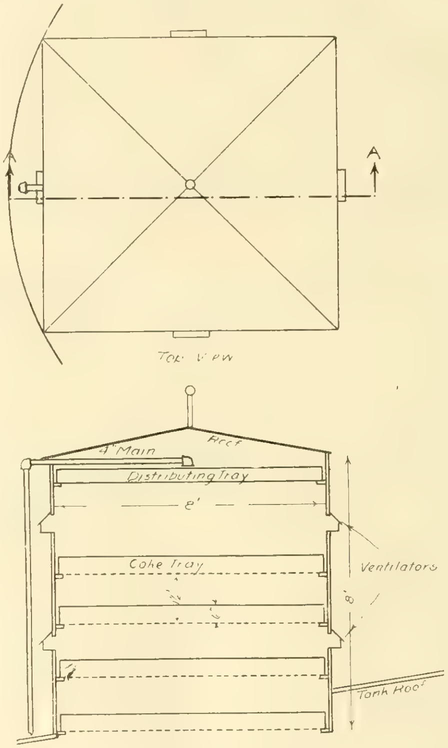
Red Water at Cranbury, N. J.

The water supply for the village of Cranbury is taken from a well 8 in. in diameter and 264 ft. deep. It was driven through clay formations and is a flowing well. The water was formerly pumped from the well into the mains, and the excess water was forced into a 40,000-gal. wooden storage tank.

For several years the water was of satisfactory quality and then complaints in increasing number were made because of the iron in the water supply at the houses. An investigation of the conditions made by the State Department of Health clearly demonstrated that the well water was practically free of iron, 0.2 part per million being present, but also showed that the well water contained from 31 to 35 parts per million of carbon dioxide, and had an alkalinity ranging from 4 to 8 parts per million and a hardness of 19. The combination of the low alkalinity and high carbon dioxide content was particularly favorable conditions for the corrosive action of the water on the mains.

In 1913 the water company installed a lime dosing apparatus consisting of slaking tank, mixing tank and pump. The charge of lime (100 lb.) is put into the slaking tank, then slaked into a mixing tank below, having a capacity of 300 gal. An automatic stirring apparatus keeps the contents of the mixing tank thoroughly agitated. From the mixing tank a small adjustable stroke chemical pump forces the lime solution into the main and distribution system.

This method reduced the CO_2 to about 3.5 p.p.m., but was open to the objection that the lime was liable to cause incrustations in the service pipes owing to the fact that only a small part of the treated water underwent sedimentation in the storage tank, most of it going to the distribution system directly, and also because the red water troubles were not entirely abated. Iron was found by analyses to be present in the water supply on several occasions in quantities as high as 2.0 parts per million.



Arrangement of Aerator, Cranbury, N. J.

The water company decided, in accordance with advice from the State Department of Health, to pump all the treated water into the elevated tank for sedimentation, and furthermore to install a coke aerator over the tank, for the purpose of aeration and release of the residual carbon dioxide remaining after treatment with lime.

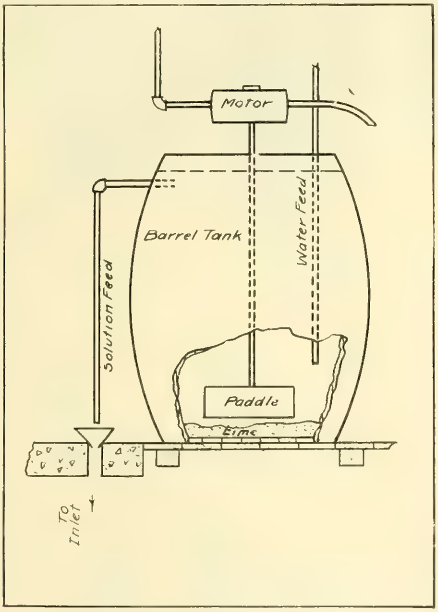
The aerator as installed consisted of a tower 4 ft. square and 8 ft. high. There are four coke trays in the tower, 1½ ft. apart, each tray containing 6 in. of coke, held in place on the under side by a fine screen through which the water drips. Above the coke trays is a distribution disc on which the water from the 4-in. galvanized iron main falls. The overflow from this disc falls upon the coke underneath, percolating through the four layers of coke in succession, finally reaching the water tank beneath. The tower is enclosed and roofed in, air being supplied from 8 ventilating boxes, 8 in. x 12 in., at each coke tray. These ventilators are open on the under side, the opening having a screen to keep out birds.

Immediately after the aerator was put in service, January, 1915, analyses showed that not only all the CO_2 was removed, but that an excess of lime was being added. The amount of lime was materially reduced, the plant using 33 lb. of lime per month instead of 100 lb. This gives a dose of about 11 p.p.m. of lime, showing that the lime accomplishes approximately one-quarter of the CO_2 removal, aeration removing the remainder.

The iron content of the treated water has since been uniformly low, varying from 0 to 0.3 of a part per million. Hydrated lime instead of quick lime has been used since the aerator was put into service.

Red Water Trouble at the New Jersey Sanitorium for Tuberculosis Diseases at Glen Gardner, N. J.

Shortly after the installation of a rapid sand filtration plant trouble was experienced with red water in the hot water system of the institution. The iron in the water supplied to the institution varied from 1 to 40 p.p.m. This trouble, on investigation, appeared to be due to the corrosion of the iron piping by the carbon dioxide held in solution in the water after treatment with alum. No provision had been made in the design of the plant for removal of these gases by aeration, and it was found that the installation of an aerator would involve the laying of about 1,000 ft. of pipe in rocky soil at a prohibitive cost. Analyses made early in 1915 showed that the free carbon dioxide in the filtered water varied from 3.08 p.p.m., using one-half grain of alum per gallon of water to 20.46 p.p.m. when using 3 grains of alum per gallon of water. It was necessary at times to use this large dose of alum (3 grains per gallon) on account of the high turbidity of the raw water.



Lime Mixing Apparatus at Glen Gardner, N. J.

Because of the impracticability of installing an aerator, due to the high cost, it was decided to try some form of lime treatment. A barrel was set up to hold the lime solution and was equipped with a paddle rotated by a small water motor. A constant flow of water through a ½-in. pipe was supplied at the bottom of the barrel to dissolve the lime, and the outlet pipe leading from the top of the barrel to the sedimentation basin, discharging in front of the pipe leading to the filter.

The plant is operated 7 hours a day, supplying 75,000 gal. of filtered water daily. With an average of 3.5 p.p.m. of carbon dioxide in the water, approximately 4 lb. 3 oz. of lime in solution would be needed to neutralize it. The water feed was regulated so as to add 400 gal. in 7 hours, thus giving, theoretically, with the above amount of lime a solution containing 1,260 p.p.m. of lime. From actual tests it was found that the amount of lime in solution varied from 1,190 p.p.m. to 530 p.p.m. Several adjustments and changes were made during this period, however, which probably interfered with the constancy of the lime feed. It was found that best results were obtained by adding 2 lb. 1⅛ oz. of lime every 3½ hours, instead of 4 lb. 3 oz. every 7 hours.

Since the installation of this lime feed the free CO_2 in the filtered water has been reduced at times to less than 0.02 p.p.m. and averages less than 0.2 p.p.m. Red water complaints have been eliminated entirely and the experimental plant, which has been in use for over a year, will be replaced by a permanent installation.

These plants differ both as to their source of supply and as to the source of the free CO_2, the CO_2 at Cranbury being present in the water in a natural state, and the CO_2 at Glen Gardner being produced by the action of alum on the dissolved carbonates in the surface water.

It is entirely probable that the carbon dioxide at Cranbury could have been entirely removed by the addition of an increased quantity of lime, but the water company being small, objected to this procedure, because of the increase in operating expenses.

INSTRUCTIONS FOR METER READERS.

The Terre Haute, Ind., Waterworks Co. issues the following instructions to its meter readers:

Mr. Meter Reader:

Please remember that you are the personal representative of the manager of this company; that our patrons will judge the company and the manager by you, by your conduct, and by what you say.

Politeness is cheap, but it pays big dividends.

If location of meter is not shown on card, make proper entry.

Endeavor to return reading of every meter for which you have a card.

Meter well covers should be carefully replaced and locked.

Make record under "Remarks" by number when possible. The figure 13 opposite a reading will mean that you had noticed the high consumption and that you were sure that the reading was correct.

Do not return an unusual reading without an explanation, and when anything out of the ordinary is noticed, call attention to it by one, or more, of the numbers.

Refer all requests as to the quantity of water consumed, or to the amount of the bill, to the office.

Report at the office about 5:45 P. M.—not later. Telephone particulars if you cannot come.

Get acquainted with the numbers and use them.

When meters are in basements, let the people know that you are there to read the water meter. If the occupants are away, do not attempt to get in—if anything was missing you might be blamed.

Be sure to close all trap doors. Remember the Golden Rule.

The numbers for recording various conditions follow:

1. Meter not registering.
2. Closet in basement leaking.
3. Closet on 1st floor leaking.
4. Closet on 2d floor leaking.
5. Closet was leaking—been repaired.
6. Kitchen faucet leaking.
7. Bath tub faucet leaking.
8. Basin faucet leaking.
9. Meter coupling leaking, inlet.
10. Meter coupling leaking, outlet.

11. Meter registering slowly, indicating a leak.
12. Did not find any leaks.
13. Consumption high; reading is correct.
14. Consumption low; reading is correct.
    Meter registers when faucet is open.
15. Covered, could not read.
16. Could not get in house.
17. Premises vacant.
18. Glass broken.
19. Counter broken.
20. Meter well needs attention.

CONSTRUCTION FEATURES OF CONCRETE DAM FOR OTTUMWA, IA., WATER WORKS.

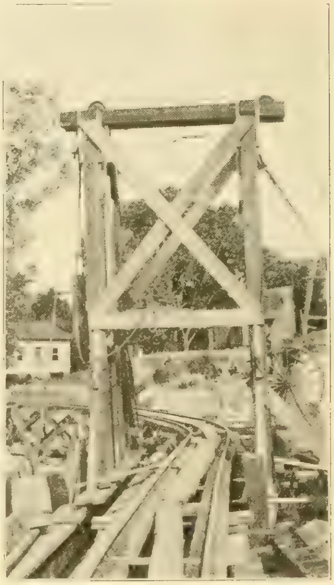
Early in August, 1914, the city of Ottumwa, Ia., began the construction of the first of two concrete dams designed to replace old timber crib structures that for many years had furnished power for the operation of the local water works plant. The Des Moines River at this point has two channels, being separated by what is known as Turkey Island. The first work was undertaken on the West Channel, and this dam was completed on Nov. 29, 1916.

The first cofferdam, which completely shut off the west channel, was constructed of wakefield sheeting supported by waling timbers carried on bents of round oak piling, the bents being placed 8 ft. apart and thoroughly cross braced.

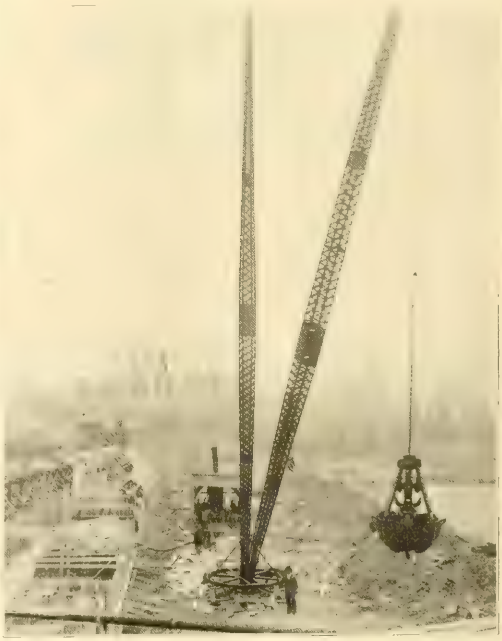
This cofferdam was completed about Sept. 1, 1914, and work was begun on the removal of the old timber crib rock-filled dam, which was to be replaced with concrete. During the night of Sept. 14 the river rose 7 ft., an almost unprecedented rise; the flood waters swept around the west end of the cofferdam, quickly cutting back about 150 ft. into the bank and then scouring out the gravel and sand bed of the river, undermining the cofferdam, which by noon of Sept. 15 had been nearly half destroyed, the remaining part of it being about 2 ft. under water. After the flood waters had receded, about the last of September, the contractor decided to attempt to repair the existing cofferdam, but after three weeks of futile work it was given up and a new cofferdam started near the head of the island.

Final Cofferdam, Composed of Timber Cribs and Wakefield Sheet Piling.

This second cofferdam, of the same type as the first, was practically finished Nov. 15. On closing off this dam several bad leaks developed, the water in places coming under and through the sheeting, which had been broken in driving. The contractor at this point became disheartened and threw up the job. The second day after he quit a 40-ft. hole developed in the cofferdam. The Ottumwa Water Works immediately took charge of the situation and a force of men was put to work closing the gap. A timber crib 18 ft. x 20 ft. and 18 ft. high was built and floated into the gap, weighted with rock and sunk. This left an opening on each side of the crib which was closed with improvised gates and immediately backed up with rock. The cofferdam was then strengthened in several other places and made reasonably tight.



Piledriver on Rolls Spanning Track on Cofferdam.



View from West End of Dam, Looking Toward the Island, Showing Orangepeel Excavating for Foundation of Dam.

In December, 1914, bids were again taken and the work let to the J. W. Turner Construction Co. of Des Moines, Ia., which at once put a force of men at work further strengthening the existing cofferdam. This, however, became undermined and broke through in the latter part of January, 1915, and after several unsuccessful attempts at closing the break with log cribs the work was given up until after the spring high waters had passed.

Work was resumed several times during the summer of 1915 only to be stopped by the rising waters of the river. Finally, in January, 1916, the cofferdam was again on the verge of completion, only to be completely wrecked by one of the worst ice gorges that ever formed in the Des Moines River. Work was then given up until more favorable conditions presented themselves.

Screening and Washing Plant for Gravel. Shows Also Track to Mixer and Head Frame of Transporter Cableway.

Early in July, 1916, work was again begun on the cofferdam shown by the accompanying illustration. This was composed of 13 timber cribs 18 ft. x 20 ft. in plan and averaging about 12 ft. in height. The 12-ft. gaps between cribs, 13 in number, were spanned by heavy waling timbers and a line of wakefield sheeting driven across the river on the upper side of the cofferdam. A track was then laid across on top of the coffer and dirt from the island carried out by side dump cars and deposited against the sheeting. This made a very tight and satisfactory cofferdam which served, without further trouble, to complete the work.

The site of this cofferdam was a very short way upstream from the old crib dam and below the site of the first cofferdam. It was built upon a bottom that was composed largely of one-man rock and willow mats made tight by the sand and gravel that had been deposited on it by the river. This material had been placed there in former years in futile attempts at stopping the leaks in the old original crib dam.

This cofferdam was completed the last of August and work was then begun on the new concrete dam, which in the meantime had been relocated immediately below the original timber crib dam which was constructed in 1876.

The new concrete dam is built upon a lime rock foundation, and varies in height from 20 ft. to 22 ft. It has a uniform width of 18 ft. 6 in., and is of the ogee gravity type. It is 330 ft. long and has a 6-ft. sluiceway and a 4-ft. fishway, both located on the island end of the dam.

The sand and gravel for the work was obtained from the bed of the river below the site of the dam, a Dull back-dump dragline bucket being used for this purpose. The material brought in by this outfit was deposited on a flat shelf in a hopper from which it was washed over a flat screen which separated the sand and gravel as well as washing them. The water for this purpose was furnished by a 6-in. centrifugal pump driven by electric motor, which also kept the leakage from the cofferdam and the seepage through the gravel bar under control.

The concrete was mixed in the proportion of 1 part cement, 3 parts sand and 5 parts gravel, Hawkeye Portland cement being used exclusively.

A 1-yd. orange peel bucket handled by a steel derrick with 77-ft. mast and 70-ft. boom served to do all the excavating.

The concrete was mixed with a Smith mixer of ½-yd. capacity, which with the gravel plant was located on the island end of the dam. The cement was delivered with teams and motor trucks at the mainland end of the dam and carried to the island by means of a cableway, which was also used to handle the forms.

The dam was built in sections 48 ft. in length having triangular vertical keyways, 12 in. on each side and spaced 18 in. apart, at each joint.

The forms were of wood faced with steel plates and were built in sections 12 ft. long, one set being used for the entire job.

The gravel and sand were chuted from bins into Koppel side dump cars and hauled up an incline to the mixer, a line from the cableway engine furnishing the power.

Mixer Plant on Dam. Discharged in Cars Running Along the Structure.

The mixed concrete was dumped into a steel hopper from which it was taken by side dump cars and transferred to the forms, a double-track trestle having been constructed for this purpose. The cars were dumped into chutes which carried the concrete to the bottom of the forms without excessive drop.

The dam contains 4,380 cu. yd. of concrete, 4,000 of which were run in 49 calendar days working 10 hours per day.

The contract prices were as follows: Cofferdam at lump sum of $4,000, earth excavation at $1.25 per cubic yard, rock excavation at $2.50 per cubic yard, concrete at $5.65 per cubic yard.

The dam was designed by Horace A. Brown, C. E., for the Ottumwa water works, H. L. Waterman, H. C. Williams, S. C. Turner, Trustees, and was constructed by the J. W. Turner Construction Co. of Des Moines, Ia., with Horace A. Brown acting as superintendent of construction.

OPERATING RESULTS OF PANAMA CANAL ZONE FILTRATION PLANTS.

Excellent results have been obtained in the operation of the Mount Hope and Agua Clara purification plants in the Panama Canal Zone by reducing the amount of free carbonic acid in the settled water. The Mount Mope plant has been in operation since Feb. 23, 1914, and supplies filtered water to a population of about 37,000. The plant comprises the following units: Aeration basin, sedimentation basin, rapid sand filters, clear water basin and chlorinator. The Agua Clara purification plant has been in operation since Dec. 29, 1911. It supplies filtered water to a population of about 1,900. It comprises the following units: Mixing chamber, sedimentation basin, rapid sand filters and clear water basin.

The accompanying tabulations, furnished by Mr. Geo. C. Bunker, physiologist in charge of Canal Zone water purification, give operating results of the filters.

Agua Clara Purification Plant—During the month of December, 1916, the quantity of applied lime was so regulated as to yield a settled and filtered water with a slight carbonate alkalinity at all times. The following table furnishes a comparison between September's operation with a settled water of low free carbonic acid and December's operation with a settled water of low carbonate alkalinity.

	September, 1916.	December, 1916.
Filter runs in hours:		
Average	11.5	73.4
Maximum	52.0	107.7
Minimum	2.7	33.9
Number of filter washings	53	10
Volumes of water, U. S. gal.:		
Filtered	20,592,000	25,823,000
Wash water	1,301,000	245,000
Per cent of wash water	6.34	0.95
Chemicals applied, lb. per mil. gal.:		
Lime	205	91
Aluminum sulphate	362	175
Free carbonic acid:		
Raw water	0.8	2.0
Settled water	2.7	0.0
Alkalinity as $CaCO_3$:		
Bicarbonate—		
Raw water	19.6	18.4
Settled water	16.5	17.9
Carbonate—		
Raw water	0.0	0.0
Settled water	0.0	3.4
Iron:		
Raw water	2.1	0.58
Filtered water	0.38	0.15
Color:		
Raw water	57	27
Filtered water	8	7
Turbidity:		
Raw water	19	10
Filtered water	0	0

Mt. Hope Purification Plant—The following table furnishes a comparison between August's operation with a settled water containing 7.3 parts of free carbonic acid and December's operation with a settled water containing 2.1 parts of free carbonic acid.

	August, 1916.	December, 1916.
Filter runs in hours:		
Average	15.7	39.8
Maximum	26.4	58.9
Minimum	9.1	25.5
Number of filter washings	166	58
Volumes of water, U. S. gal.:		
Filtered water	127,706,000	120,642,000
Wash water	7,686,000	2,852,000
Percent of wash water	6.02	2.37
Aluminum sulphate, lb. per mil. gal.	195	128
Free carbonic acid:		
Settled water—		
Average	7.3	2.1
Maximum	10.2	2.5
Minimum	4.5	1.8
Raw water—		
Average	1.6	1.8
Maximum	2.5	3.5
Minimum	0.0	0.5
Air compressors—hours of operation	215	77

THE WORK OF THE SERVICE FORCE OF THE WATER WORKS DEPARTMENT OF MINNEAPOLIS.

Contributed by J. A. Jensen, Supervisor Minneapolis Water Department.

The original water works street service force was organized primarily to take care of the various troubles arising in the operation of a water system. This work consisted of leaks and general repairs.

During the past few years the general character of the men required for this service has, from necessity, improved and the scope of the work broadened to include more diversified duties. Water departments are now required to do more than merely furnish water to the premises for ordinary use and to hydrants for fire protection. The public demands service.

Water supplies in these days are protected by sanitary regulations and subjected to various forms of purification and filtration. The consumer is given better water under improved conditions. The supplies are conserved by meterage and the user expects more attention and better service.

These demands reflect back upon the service force and have created more diversified work. The department is now required to meet the demands of the public and be prepared to respond to calls and complaints as well as to take charge of general repairs. This also has created a demand for men of better skill and ingenuity.

The force must be classified for the various duties and each class be required to do certain kinds of work. Other elements enter into the organization, such as seasonal work brought about by climatic conditions, periodical work such as turn-offs and turn-ons, and various inspections and repairs. An emergency crew is required for sudden calls on breaks or accidents.

The emergency crew in this city might be termed a modified one. In some cities a crew is kept ready to respond to call much like a fire department unit. As the number of calls would hardly justify a crew here, a plan is in effect whereby an auto truck is always ready to leave service headquarters on call during the day and suitable men for this work are employed about the shop and yard on other work which can be left on a moment's notice and the emergency rig manned by them immediately. Each so-called emergency man is supplied at the city's expense with telephone service so that if trouble should arise at night they may be called by the foreman and given instructions for duty. A night watchman and assistant, one of whom is a chauffeur, are ready at headquarters to respond to the place with the necessary implements and material for emergency work. This plan has been in operation for some time with satisfactory results.

The service force is at present classified as follows: One foreman and assistant, three clerks, one storekeeper and assistant, one blacksmith and helper, one carpenter, three shop repair men, one hostler, two night men, 17 service men and 17 assistant service men.

These men are employed under civil service regulations on a monthly basis. The service men are given time off for all overtime work, but are subject to call for duty at all hours.

On general work and minor repairs the service men with assistants work in pairs and are supplied with a single horse rig for this purpose. These rigs are gradually being replaced by light automobiles and it is found that an auto rig can more than do the work of two horse-drawn rigs. This is accomplished by decreasing the time lost in covering distant territory. In this way also the department is enabled to take care of increasing work for the time being without increasing the force.

It may be of interest to water works men to refer to some of the work encountered in this city and under existing climatic conditions in this latitude. This work is grouped under the following headings:

Fire Hydrants.

Hydrants are set with the center of the branch 8 ft. below the street grade. Maintenance work consists of testing, replacing valve leathers and other parts, oiling and painting. On account of climatic conditions constant inspection is necessary during winter to see that hydrants do not become frozen. In the congested districts hydrants are inspected daily for this purpose. In the outlying districts inspections are made about once per week.

To keep 5,627 hydrants in proper working condition 70,202 inspections were made during the year which gives an average of 12 visits or inspections per hydrant each winter. During heavy snowfall it is also necessary to uncover the hydrants so they may be readily seen if required.

The inspector tests the hydrant for frost in various ways. Sounding by the hand and test by plummet usually reveal any trouble that may require further attention, such as operating the hydrant or using thawing appliances. The cost of inspection work was 6.9 ct. per hydrant for the year.

Of the above number of hydrants, 119 required the replacing of such parts as caps, revolving nuts and packing nuts; 140 had the valve leathers replaced; 35 were taken to the shop for overhauling and 17 were broken off by traffic on the streets. Most of these were broken by skidding automobiles which went over the curb at the time of the accident. With the compression type of hydrant there were seldom cases of serious loss of water.

Large buildings which extend their area walls to the curb encroach on hydrant space. The regulations require the hydrants to be walled off from the basements in such cases to keep out the drip water. Where the basements are not heated the cold walls in this climate afford favorable conditions for frost penetration by following down the masonry to the base of the hydrants. In the congested districts hydrant branches occasionally freeze if the branch is close to a catch basin or manhole. The practice of locating hydrants on the property line at street intersections was abandoned several years ago. Now they are set back 10 ft. from the property line, thus keeping clear of the space usually occupied by catch basins.

All hydrants in use are of the Mathews type. Originally, even in this climate, it was thought necessary either to set the hydrants in brick chambers protected by shavings or to use the common form of iron frost jackets. For the past 7 years a type of hydrant has been in use which has no frost jacket or chamber. The hydrant is buried in the usual way and gives no more trouble than hydrants set according to former methods. The working parts can be removed by removing the bonnet and raising them by means of a tripod which of course must be quite high for a hydrant buried 8 ft.

The usual trouble is experienced in the use of hydrants for flushing streets and various industrial and municipal purposes. A number of regulations are in force with varying success. The users are generally incompetent to operate the hydrant properly and the service department must follow up all cases of trouble for inspection and repairs. Until municipalities recognize the necessity of authorizing and installing a special form of hydrant for other than fire purposes, this trouble must be borne as part of the routine maintenance service.

Valves.

All gate valves 12 in. and over in size are enclosed in chambers with manhole covers at the street surface. Smaller gates are supplied with iron gate jackets the upper portion of which are adjustable to grade. In the future all gates set where streets are to be paved will be enclosed in chambers as in the case of the larger gates. This will obviate the necessity for digging to jacketed gates for repacking and repairs.

All gates over 12 in. in size and inclusive are inspected and tested at least once each year besides any necessary operation for service purposes. Gates of smaller size are tested and inspected as operated unless reported in trouble. Of 5,872 gates, 2,066 were operated for service and test purposes. Of these 140 required the repacking of stems and 18 had the stems replaced. The average cost of such inspection was 16 ct. per gate requiring attention.

The city has adopted a more generous policy in the matter of placing sufficient gates in the distribution system. The original or initial installation of the system is now included in the so-called congested districts of the city. The need of sufficient gates is greatest on this portion of the mains, and unfortunately at the time these pipes were laid the gates were set far apart and hydrant branches were seldom provided with gates.

Since that time a considerable number of gates have been added to these mains. The principal difficulty in setting them has been the inconvenience caused by shutting off the water from a large number of consumers during the operation. This has been overcome by the use of a gate inserting machine which installs gates on the mains while under pressure. During the past four years 194 6-in. and three 8-in. gates have been set on mains and hydrant branches without it being necessary to shut off the water. The average labor cost of inserting a 6-in. gate, including excavating, setting the machine, cutting in, inserting and backfilling was $34.20. This machine has operated successfully in practically all cases. An eccentric pipe or one under strain binding on the cutter has in two or three cases required a shut-off to complete the work.

Leaks in Mains.

During the past year 76 leaks in water mains were repaired. Of these leaks two were of a serious nature, being the bursting of a 36-in. main of cast iron which had been in service 28 years. The metal in these pipes appeared to be in perfect condition, so the reason must be ascribed to other causes than deterioration of the iron. These breaks resulted in the loss of a considerable amount of water. Being on water works grounds no damage was done to private property. The flood at the station inundated a 20,000,000-gal. electrically driven centrifugal pumping unit. Considerable time of service of the pump was lost owing to the necessity of carefully drying out the motor. This was done by passing a current through the motor windings causing a small rise in temperature of the conductors and also by the use of toasting grids around and about the stator coils of the machine.

It may be of interest to water works men to note the classification of the leaks for a year. They have been divided as follows:

Broken gate flange	1
Broken or cracked cast-iron pipe	13
Corrosion of steel pipe	1
Expansion joints on steel pipe	12
Frozen air valve gate	1
Lead joints started, cast-iron pipe	42
Riveted joints steel pipe	6
Total	76

Of this number 17 per cent were due to broken pipes. The remaining number of leaks with one exception were confined to the various kinds of pipe joints. This fact is worthy of more than passing notice.

Service Leaks.

Service pipes in this city are laid by the property owner from the main to the premises. That portion of a service from the main to the property line is installed under inspection by the city engineer's department. Lead pipe is used from the tap to the curb stop cock. The axis of the main is 8 ft. below the street grade and after a service pipe leaves the tap it is dropped down to 9 ft. in depth.

The city furnishes the corporation cock and the curb cock. The former is included in the tapping fee, and the latter is sold for practically cost. The curb cock is of the inverted key type of the so-called "Minneapolis" pattern. The one now in use is of an improved form, the change having been made recently. The curb stop box is made up according to the specifications of the water department, but the manufacture and sale is in the hands of private concerns. The purpose of this supervision and inspection is to protect the owner against unscrupulous work on the part of the plumber as well as the city against water losses resulting from poor materials.

Leaks are repaired at the expense of the property owner. To enforce this regulation the department employs a leak inspector. His duties are to investigate all service leaks, determine their origin and notify the owner to make prompt repairs. If the repairs are not begun within 24 hours the department may call in a regular plumber to do the work and charge the expense against the property. This is to prevent the loss of water by delay or neglect on the part of the owner.

During the past year the inspector has had charge of 538 service leaks. This is the proportion of leaks incident to the maintenance of about 60,000 services. Where damage results from such leaks the department makes a shut-off in each case. This work required digging to 17 taps and four stops; turning off 62 stops and 20 leaks required the shutting off of the mains as the corporation cocks were defective.

Tapping.

Services pipes are all laid by licensed plumbers who are under bond to the city. The taps are made by the water department. The plumber excavates to the main and is required to have ample space for the work of the tapper and the pit must be free from water. If the excavation is not satisfactory the tapper may pass up the job until it is made so. Tapping orders received in the forenoon or afternoon are routed for the work on the following half day, respectively. This work is done with dispatch and the plumbers are required to co-operate to make the service efficient. Recently three horse-drawn rigs for tapping were displaced by one light automobile truck.

During the year 3,410 taps were made of the following sizes: ½-in., ⅝-in. and ¾-in. The average of labor and transportation per tap was $1.48. The average distance traveled by the truck per tap was 4.8 miles. When the change was made from horse-drawn rigs to automobile truck the reduction in cost per tap was 46 ct. or $1,560.60 for the year.

Taps from 2-in. to 16-in. in diameter are of the sleeve and valve type. Valves on this kind of connection are required to be placed in a manhole chamber. The department made 51 sleeve and valve taps during the year at about the following costs for labor: 2-in. and 3-in. taps, $6.28; 4-in., 6-in. and 8-in. taps, $12.80; 12-in. and 16-in. taps, $16.40. All taps require the usual recording by the tapper for location records. The direct and rectangular tie-in systems are used with permanent objects for the markers.

Sprinkling Standpipes.

The department has the care of 657 sprinkling standpipes. In this climate these require turning on in the spring and turning off in cold weather. Occasionally an unexpected cold snap has caught scores of these in a single night and as many as fifty had burst and were transformed into spray fountains when they thawed on the following morning. On account of objection from residents many sprinkling hydrants have to be moved to new locations and others are moved on account of street changes. Each year the valves are reseated and repaired, hose replaced, pipes threaded and the stands painted.

The average cost of installing a deep or winter standpipe was $54 and a shallow standpipe $44. The average annual maintenance cost was $3.30.

Watering Faucets.

Several years ago the health department abolished the public horse watering trough owing to the danger of spreading the various contagious horse diseases. These have been replaced by watering faucets posts at the curb at important locations. Users are required to have their own buckets for watering purposes. This post is made up from a piece of 4-in. wrought iron pipe capped at the top and having an opening for a ¾-in. pipe about 30 in. above the grade. A service pipe is tapped into the main and run up and through the post and a self-closing faucet is attached for public use. These watering posts are continually at the mercy of a careless class of people and receive rough usage. They require frequent replacement of the faucets. These posts are not in service during cold weather and at such times the faucets are removed. The upkeep charges per year was was $6.48 per post.

Turn-Offs and Turn-Ons.

The water department regulations require a turn-off for delinquent accounts with a $3 penalty to cover the expense of turning on payable in advance. Bills are rendered quarterly and duplicates are mailed to occupants of premises where bills remain unpaid or parties are reached by telephone prior to the time of issuing turn-off orders. Even with these efforts on the part of the department a great many consumers were not really recipients of regular notices and regarded turn-off regulations as being too drastic. To cover such cases the department voluntarily began the service of a 24-hour notice on the premises that a shut-off would result if payment of water bill was not made in that time. Ninety-five per cent of such cases were immediately paid. The effect of this upon the service work was at once appreciable, especially when stops are under snow and ice of winter. The payments eliminate measurements to locate the shut-off box and cutting ice to open them and operate the cock.

The turn-off notices are routed and arranged so that a morning notice is laid over for turn-off on the following day's afternoon, thus insuring a full 24-hour notice and ample time to pay. This action has also made more pleasant relations between the water department and the public. The object of the department in such cases should be to give service rather than to collect penalties. Delinquents belong to that class of human beings who are neglectful from habit, and in these cases this service has proven of benefit.

During the year 2,259 delinquents were notified in the four quarters out of about 60,000 accounts. In addition to this 1,083 turn-offs and 619 turn-outs were made and 43 stops out of order were dug up for operation. Most of these were operated by request or other reasons. Parties leaving property vacant during absence in winter pay a small fee to have the water turned off to obviate damage resulting from frozen pipes within the buildings. The unit cost per consumer was as follows: Notification, 20 ct.; turn-off, 87 ct.; turn-on, 91 ct. and cost to dig and repair stop, $7.48.

Inspection and Miscellaneous Work.

Complaints coming from plumbers or owners relative to service troubles have to be responded to and the troubles have to be remedied. Many troubles are imaginary, but have to be given attention to satisfy the complaining party. The department responded to 54 pressure complaints requiring investigation to locate causes of stoppage of flow. In a few cases calking yarn was found at the tap, but generally the troubles were stoppage by accumulations on the meter screen or other meter troubles. With 90 per cent of the services metered, the inspection and care of meters require the services of a special staff for that purpose. Complaints of dirty or unsatisfactory water required the flushing of 1,202 hydrants during the year. The water is permitted to flow until clear, requiring from two to seven minutes. All such flushing is from dead end mains. Even with filtered water the old mains carry sediment for several years, though it is noticeable that this condition is disappearing, but water in dead ends is bound to become stale and require flushing.

Stop boxes which have been raised by frost action in clay soil or left high in grading are dangerous to pedestrians and require attention every year. During one season 4,113 boxes were adjusted. Some of these required new covers which were replaced at the expense of the department. Many of these covers were broken by chopping ice off the walks in winter. All boxes now have malleable iron covers to prevent breakage.

Office and Yard.

The office clerks and storekeeper keep records of all taps, gates and the material handled. All orders for repairs, notice and turn-offs are filed for certain periods of time for reference. All supplies and materials are checked and accounted for and delivered on requisition from proper authority.

The blacksmith and carpenter perform such work as arises from the general demand of the service and construction forces. All work on construction is done by the city, and the service department is called upon to co-operate with such work while it is in progress.

All work is arranged in a systematic way, so that the various duties are carried out without confusion or delay with a purpose to meet the demands of the department and the requirements of the public.

RULES GOVERNING DESIGN OF SEWAGE TREATMENT PLANTS AND OUTLET SEWERS.

Fourteen specific rules governing the design of sewage treatment plants and outlet sewers in New York City have been adopted by the Board of Estimates and Apportionment of that city. These rules are the result of conferences between the consulting engineers of the several boroughs of the city, the engineers of the borough sewer bureaus and the engineering staff of the Board of Estimates and Apportionment. The principles will apply to all boroughs. The rules follow:

Rule No. 1. The volume of sewage intercepted to treatment plants shall be:

(a) For separate system, the maximum flow.
(b) For combined systems:
    1. To grit chambers, three times the mean dry weather flow, where grit chambers only are to be provided; elsewhere, the capacity should be equal to that of subsequent treatment processes.
    2. To fine screening plants, three times the mean dry weather flow, except in those cases where the cost of interception and pumping would be excessive, in which case the volume shall be limited to two times the mean dry weather flow.
    3. To sedimentation plants, two times the mean dry weather flow.

Rule No. 2. The interception of sewage should be controlled to within 20 per cent of the assumed intercepted flow.

Rule No. 3. Outlet sewers shown on drainage plans, where it is proposed to treat sewage by screening, should provide for a loss of head for the operation of the screens as great as 1 ft., where practicable.

Rule No. 4. For all but exceptionally large sedimentation plants, such as have been proposed for Barren, Ward's, and Riker's Islands, a loss of head due to the flow through the plant amounting to 1 ft. shall be provisionally assumed.

Rule No. 5. The methods of sampling and analyzing sewage and sewage effluents to determine the results of processes for treatment shall be those adopted by the American Public Health Association.

Rule No. 6. Outlet sewers shall be constructed at as high an elevation as is consistent with proper gradients and adequate drainage.

Rule No. 7. The hydraulic grade at the outlet shall be assumed, in the design of the outlet sewer, to be not lower than the level of mean tide, except where the top inside of the sewer is submerged more than 20 ft. below the elevation of M H T, in which case the hydraulic grade shall be assumed to be not lower than the level of M H T, plus 0.15 ft. for every 10 ft. of submergence.

Rule No. 8. If the sewage is delivered by gravity to a fine screening plant having screens of the Riensch-Wurl type, or to a sedimentation plant, and thence to the outlet, the hydraulic grade at the outlet in the harbor during periods of maximum sewage flow shall be assumed at 35 per cent of the mean tidal range at that point above the level of the mean high tide. The upper ends of Hamburg or other band screens can be carried sufficiently high to avoid drowning out during high stages of tide and so can be designed with the hydraulic grade at outlet at the level of M H T.

Rule No. 9. If the sewage is pumped to a fine screening plant having screens of the Riensch-Wurl type or to a sedimentation plant, the hydraulic grade at the outlet in the harbor during periods of maximum sewage flow shall be assumed at not less than 50 per cent of the mean tidal range at that point above the level of mean high tide.

Rule No. 10. Effluents from fine screening and sedimentation plants shall be discharged at or beyond the pierhead line when practicable.

Rule No. 11. In establishing the hydraulic grade of the sewage entering a screening or sedimentation plant from which the effluent passes by gravity to the outlet there should be added to the hydraulic grade at the outlet (as given in Rules No. 8 and No. 9) the head lost in the outlet sewer between the plant and the outlet at times of maximum flow, plus 1 ft. loss of head in passing through the plant.

Rule No. 12. Where separate or combined outlet sewers constructed under piers are not to be submerged or built beyond the end of the pier the outlet should be carried to a point within 30 ft. of the end of the pier.

Rule No. 13. Where the submerged outlet sewer extends beyond the pierhead it shall be laid so as to avoid obstruction to either the actual or the legal channel or waterway and so as to avoid injury by dredging operations or the dragging of anchors. Where this condition can be fulfilled the discharge shall be approximately in a horizontal direction; otherwise, in order to bring the outlet above the stream bed, the pipe may terminate in a bend.

Rule No. 14. Wherever practicable, submerged outlets shall be placed not less than 50 ft. beyond the pierhead line nor in less than 30 ft. depth of water over the top inside at M L T.

SILT DETERMINATIONS IN THE LOWER COLORADO RIVER.

Since 1909 silt determinations in the lower Colorado River have been made, at the Yuma Gaging Station of the U. S. Reclamation Service. These observations made by the Reclamation Service, representing the recording of over 4,000 separate determinations of silt content, have been compiled in a recent report of Project Manager L. M. Lawson. The report is summarized in the May Reclamation Record, from which the following notes are taken:

A study of these records brings out a number of very interesting facts, which may be summarized as follows:

1. The maximum percentage of silt during rising stage is carried at a discharge of approximately 26,000 second-feet, which is also the stage at which the river at this point reaches its maximum velocity—6.2 ft. per second. During the falling stage of the river, the maximum percentage of silt is carried at a somewhat higher discharge.

2. The maximum percentage of silt by weight observed is 4.16 per cent.

3. The mean silt content and percentage by weight, 1909 to 1916, of the Colorado River at Yuma, without Gila flow, is 0.70 per cent. At times of Gila discharge, this percentage is 0.93.

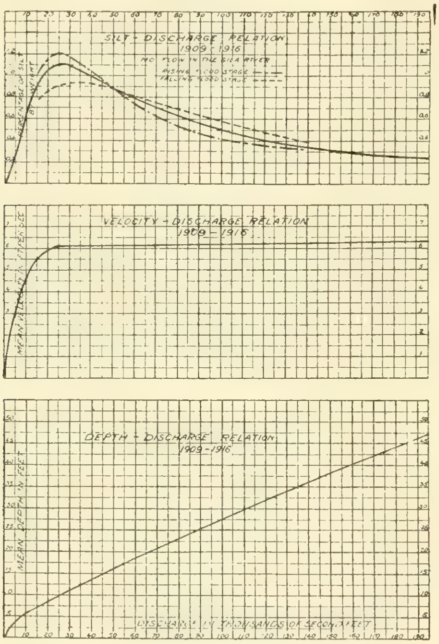
4. The weight of wet deposited silt per cubic foot when dried is 86 lb.

5. The weight of 1 cu. ft. of solid dried silt is 159.3 lb.

6. The specific gravity of the silt is 2.6.

The restricted channel width at this station and the accommodation of flood flow by deepening of the channel affords an unusual opportunity for the study of the phenomena of silt carriage and scour. The relationship between discharge, velocity, silt content, and scour of channel is strikingly shown in the accompanying curves. They show that the velocity increases with the discharge until it reaches approximately 6 ft. per second, and from that point on the increase in area of the channel due to scour balances the increase in the discharge and the velocity remains practically constant; also as the discharge increases above 26,000 second-feet without increasing velocity, the percentage of silt falls.

A comparison of the quantity and weight of the silt carried by the Colorado River with that of other well-known streams is of interest. Humphreys and Abbott give the quantity of silt carried by the Mississippi River yearly to the Gulf as 250,000,000 cu. yd. Sir Benjamin Baker calculated the Nile deposited 40,000,000 cu. yd. in the Mediterranean each year. Records of the Yuma gaging station show that the Colorado carries annually to the Gulf of California 184,000,000 cu. yd. Follett in a report on the Rio Grande silt gives the average weight when dried of 1 cu. ft. of wet deposited silt as 53 lb. Coghlan, after investigation, places this at 92 lb. Hughes gives the mean of Gila River silts dry as 76.1 lb. per cubic foot. As stated above, the determinations of the Colorado silt at Yuma give a weight of 1 cu. ft. of wet deposited silt when dried as 86 lb. The specific gravity of Rio Grande silt is stated as 2.64. Hughes gives the Gila River silt as having a specific gravity of 2.55. The results of 20 determinations on the Colorado silt give specific gravity of 2.6.



Relationship Between Discharge, Velocity, Silt Content and Scour of Channel.

Cost of Pumping Water.—The following figures from the report of the quartermaster general of the U. S. army for the fiscal year 1916 give a comparison of the estimated cost of pumping water in 39 pumping plants in Massachusetts with the cost of similar work done by plants of the quartermaster corps in the Philippine department; figures are per 1,000 gal. pumped:

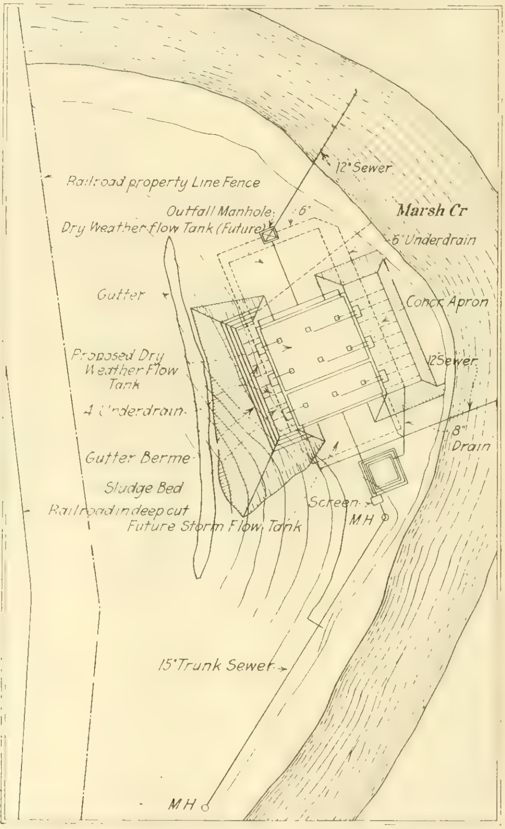
	Massachusetts.	Philippines.
Average	$0.115	$0.151
Minimum	.065	.078
Maximum	.257	.274

SPECIAL FEATURES OF SEWERAGE DEVELOPMENT AT WELLSBORO, PA.

Contributed by Henry W. Taylor, Consulting Engineer, 26 Cortland St., New York.

In laying out additions to the sewer system of Wellsboro, Pa., it was found necessary to introduce some special features in the disposal plant design in order to meet the conditions imposed by an existing combined sewer system and the special requirements of a small plant.

Wellsboro is located in Tioga County, Pennsylvania, and is a borough with a population of about 3,500 people. Some $60,000 already has been expended on sewer construction. These sewers are combined and it is beyond present financial possibilities for the borough to make an absolute separation of storm water and domestic sewage.

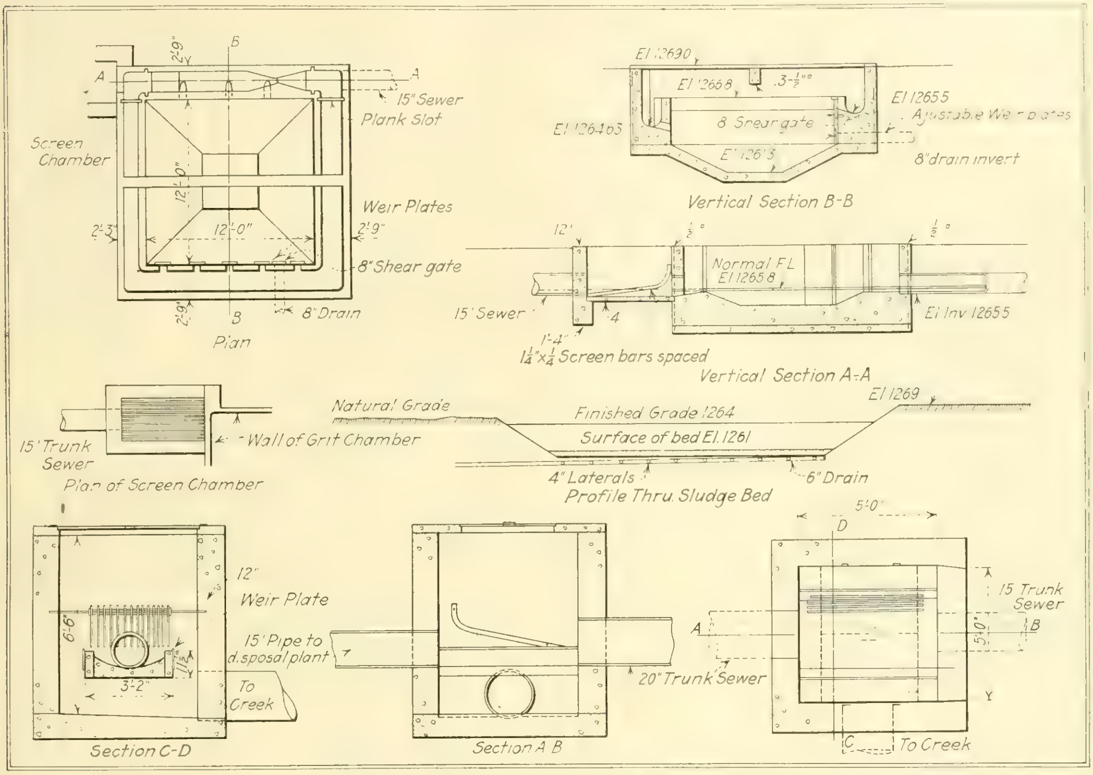


Layout of Sewage Disposal Works.

The situation is considerably relieved, however, by the fact that the borough is cut by three branches of Marsh Creek, each of which affords opportunity for short lines from existing catch basins for the separation of storm water and the gradual removal of same in the main from the sewer system. However, the main streets have recently been paved and it would be impossible to lay new sewers along these streets without ruining these pavements and also incurring an expense which could not be met for years to come. A policy of gradual separation therefore has been adopted, while separation on paved streets will not be made till these pavements need renewal.

In designing additions to the present system, the new trunk lines and their laterals were designed on the separate system and will be used for sanitary sewage only.

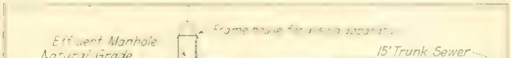
In certain unpaved streets of the borough, where the sewers at present are surcharged during storms, the present scheme of giving over these sewers to domestic sewage was adopted and the exclusion of storm water from these sewers is to be obtained by short storm water lines to one of the three branches of Marsh Creek. The paved streets, however, could not be so cheaply treated and it is impossible at once to eliminate all the storm water from these sewers. In order to meet this situation the disposal plant has been designed on the basis of treating during storms a volume of sewage and storm water, equivalent to three times the normal dry weather flow. The excess volumes of storm water, should there be any, are to be discharged at suitable places into the creek. Any sewage thus reaching the creek will have experienced a dilution in excess of 2 to 1, while during such times the flow of the creek will be at least 5 times its minimum dry weather flow and a resultant dilution will at once take effect in the percentage of at least 10 to 1 in terms of the dry weather flow of sewage. Due to the flashy character of the stream, the probable dilution will be about 25 to 1.



Details of Typical Sections of Sewage Disposal Works.

The outlet of the existing trunk sewer is at a peculiarly bad location as it discharges into Marsh Creek at a point where this creek parallels the main entrance to the village for a distance of over 1,000 ft., and where it runs within 50 ft. of the curb of this street. During dry weather flows of the creek the amount of dilution is inadequate and deposits have been formed which have given rise to a serious and objectionable nuisance.

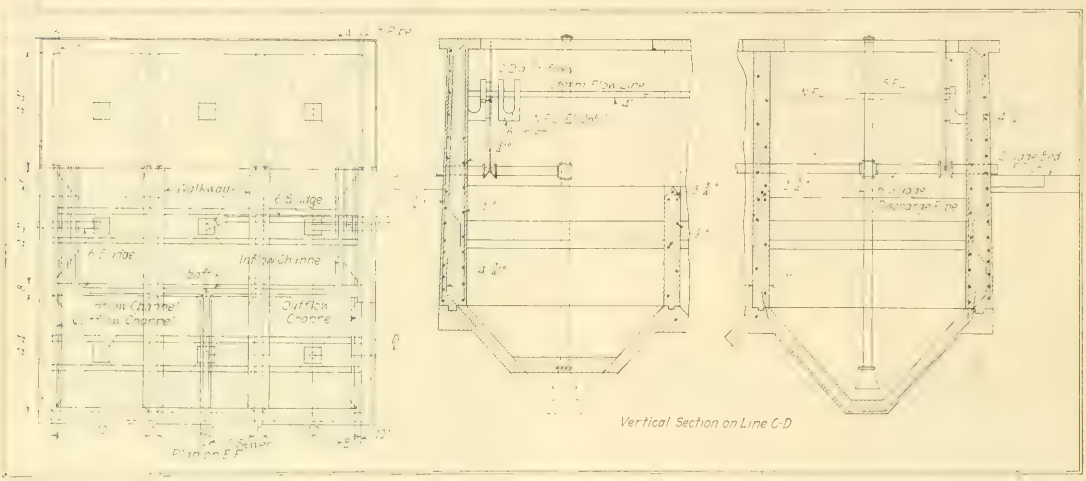
The plans call for the extension of this outlet by a 20-in. pipe with a capacity such that no overflow will occur from the sewer at this former point of discharge until the flow equals at least 16 times the normal dry weather flow. From the best information obtainable, it would appear that such a condition would take place not more than two or three times a year and at such times as this overflow will take place, the stream itself will be at high water stage and provide a dilution of over 60 to 1. Where the new trunk sewer extension joins the existing sewer there is to be installed an overflow manhole which will act as an occasional relief at this point. Sixteen volumes of sewage and storm water will be carried through this 20-in. sewer for a distance of about 2,500 ft. where a second overflow manhole is to be installed. This latter overflow manhole makes a final reduction of storm water flows so that two volumes of storm water will be carried on to the disposal plant and the remainder of the flow which reaches this point will be discharged into the creek at an unobjectionable location. The overflows at this point will consist of sewage and storm water combined in a ratio in excess of 16 to 1, while by the plan of conducting to the plant the first two volumes of storm water the creek is given



Longitudinal and Transverse Profiles Through Works.

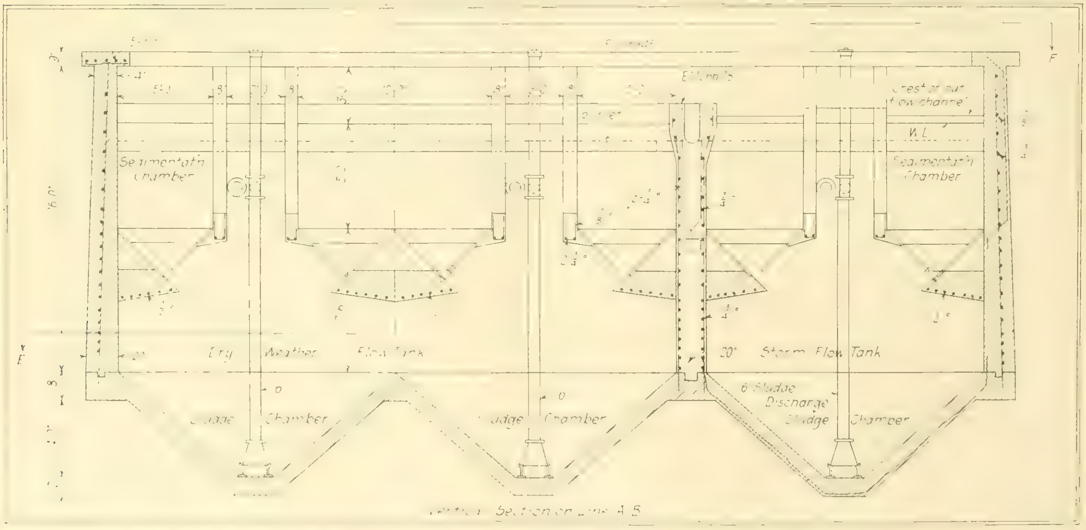
an opportunity to largely increase its volume and its power of dilution.

The three volumes of domestic sewage is then carried forward to the disposal plant site. The present domestic flow of sewage is about 300,000 gal. per day and the flow during storms to be conveyed to the disposal plant will thus be at the rate of about 900,000 gal. per day. The sewer to the disposal plant, however, is of sufficient capacity to allow for twice the flow of sewage during dry weather and twice the storm water flow, so as to maintain a consistent ratio of three times the dry weather flow for treatment.



Details of Sewage Disposal Works, Wellsboro, Pa.

The disposal plant consists of a grit and screen chamber, Imhoff tanks, sludge beds and the necessary outfall sewers. In the design of the disposal plant it was necessary to provide some automatic arrangement by which a sufficient capacity is provided for a flow of 900,000 gal. per day while avoiding an undesirable detention for normal flows of 300,000 gal. per day. With a plant of this size it is assumed that constant maintenance throughout the day will not be provided and consequently hand control during storms is out of the question.



Details of Sewage Disposal Works, Wellsboro, Pa.

This same idea applies very particularly to the grit chamber. If a chamber which would be adequate for storm water conditions were used also for the normal flows, an undesirable deposition of organic matter would take place. In fact the grit chamber required for domestic flows is comparatively nil, while the Imhoff tanks must be protected against sand and grit which will undoubtedly accompany storm water flows. In the case of the grit chamber no hand control can be relied upon and furthermore moving part apparatus would probably be ineffective in the long run. The scheme finally adopted is shown diagrammatically in the accompanying sketch and the operation of the chamber may be described as follows:

The normal flow of sewage leaves the 15-in. sewer and is discharged into a channel in the wall of the grit chamber, which considerably enlarges the section of flow and provides, for normal conditions, a small amount of grit sedimentation. Holes in the bottom of this channel allow any deposited matter to slide into the grit chamber itself, while under normal flow conditions the sewage is really by-passed around the grit chamber and merely passes through an enlarged section of flow and back into a 15-in. sewer which carries it to the Imhoff tanks. In the opposite wall of the grit chamber there are five small wiers with adjustable plates, and these plates are set slightly above the normal flow levels in the sewer for domestic flow conditions. As soon as the water rises in the sewer, due to an augmented flow from storm water, the water level in the grit chamber rises and these wiers come into operation and thus induce a flow of sewage through the holes in the bottom of the dry weather flow channel in the opposite wall.

Furthermore, in the channel, for normal flows, there is provided a contraction in the channel, which is only 4-in. wide, but deep enough to afford the required area for normal flows. As the water rises in the sewer the additional area in this flow section is increased by a comparatively small amount, due to the shape of the section. This section is also contracted at the top by a plate so that for any flows other than normal flows the section is converted into an orifice which offers resistance to the direct flow to the plant and consequently a flow through the grit chamber is the line of least resistance.

This arrangement, of course, is not theoretically exact, but without the use of hand control or moving part apparatus is perhaps as close an approximation as can be arranged simply to meet the requirements. The wiers in the end wall of the grit chamber will, of course, operate as submerged wiers and their purpose is merely to form a lip of overflow slightly above the domestic flow line, so as to eliminate flows under dry weather conditions. These wier plates are adjustable and will be set in the field to meet actual conditions and can be reset from time to time to meet increased flows.

In the design of the Imhoff tanks, one unit is continuously used for the dry weather flow and affords for this flow an average detention of three hours. The Imhoff tank layout is shown diagrammatically in the accompanying sketch. There are two separate tank units provided, one unit being designed for a 3-hour detention for the normal flow of 300,000 gal. per day. The storm water tank unit adjacent to the first is of one-half the capacity of the latter unit and during storm flows both units will be used together to afford a detention of 1½ hours and will serve three times the dry weather flow.

The problem of throwing the storm water tanks into use at the proper time has been hydraulically accomplished as follows: The normal dry weather flows are carried to the normal flow unit by an overhead concrete channel containing openings in the bottom of the channel so that the water levels in the two tanks will always be at the same elevation. The outlet channels of the domestic flow tank contain orifices about 2½ in. in diameter. These orifices will take a flow of 300,000 gal. per day when operating under a head of about 2½ in. During times of storm water flow, these orifices will resist increased flow and cause the water level in both tank units to rise and when the water level in both tanks has gained about 4 in. the orifices in the normal flow unit will be carrying about 600,000 gal. per day. In the case of the storm water unit the outlet channel contains wiers which are set at an elevation of about 3½ in. above the normal water level in both the tanks. Since these wiers are out of reach of the normal water levels no flow takes place through the storm water tank until the water elevation in this tank has risen to the height of the wiers.

This rise in water level takes place during storm flows and the wiers in the storm unit are thrown into operation when the carrying capacity of the orifice outlet of the dry weather flow tank has nearly reached the desired amount. As the storm flow decreases the orifices of the dry weather flow tank begin to gain on the inflow to the tank and the water level is thus lowered to its normal level. By this hydraulic arrangement, the storm water tank, without the use of hand control or moving part control, is automatically thrown into service and similarly is thrown out of service when the storm water flow ceases.

From year to year, additional work on storm water separation will be done. No new storm water will be allowed to enter the trunk sewer and as time goes on the dry weather flow in the trunk line will increase and be at least twice present flows. As the present volumes of storm water decrease and future flows of domestic sewage increase it is probable that no appreciable storm water overflows will take place at either of the overflow manholes.

Another problem which had to be met in connection with the design of the disposal plant was the selection of a location which would be suitable for the tankage at present required, would not over-run in expenses moneys available for its construction and still would be adjustable to the addition of future disposal works when these are required in the future. The site used for the tanks, sludge beds, etc., is on a plateau adjacent to the creek and lying in one of its angles. There is not sufficient area to allow for sprinkling filter development at this same site and, on the other hand, if the trunk sewer were extended at present to a point whose topography permitted of economical filtration construction, the expense of this trunk sewer would be such as to make the sewer construction and disposal plant construction impossible for many years to come.

Beyond the tankage site is a flat some 1,500 ft. distant, which lends itself admirably to filtration construction. It also happens that the fall in the creek at this point amounts to some 2 ft. and this drop added to the fall available at the tankage site makes easily possible the operation of a sprinkling filter without pumping. The situation also was complicated by the two volumes of storm water at the tanks and if the raw sewage together with this storm water were carried to the further disposal site, very expensive excavation would have been required in rock and this cost would have blocked proposed construction.

The plan adopted consists of developing a site of small area for present and future tankage and sludge bed areas. The area is ample for this purpose and is unusually secluded and still accessible for operation. When future disposal works are required the expensive construction mentioned above can be obviated by installing an inverted siphon extending from the tanks to the dosing chamber of the sprinkling filtration units at the lower location. This construction will be comparatively inexpensive inasmuch as the additional volumes of storm water will not need to be carried to this point and the settled sewage can be much more economically handled by special means than the raw and untanked sewage. The scheme involves no elements which will interfere or increase the cost of future development and at the same time obviates a present expenditure which would make any construction at all impossible for the present.

Filter Operations at Columbus, O.—The average rate of filtration at the plant of the city of Columbus, O., for 1916 was as follows:

	Volume of Water, Million Gallons Per Day			Plant in Operation		Average Rate of Filtration, Million Gallons Acre Daily.*
Month	Average Delivered to Mains.	Maximum Delivered to Mains.	Average Wash and Waste Water.	Number of Days.	Average Hours per Day.	
January	18.6	23.5	[illegible]	31	24	[illegible]
February	19.1	22.0	.218276	[illegible]	24	108
March	18.1	19.2	.193790	31	24	102
April	17.4	18.9	.164875	30	24	[illegible]
May	18.5	20.3	.148040	31	24	91
June	19.0	21.6	.193725	30	24	94
July	[illegible]	26.8	.220839	31	24	147
August	23.0	26.2	.187137	31	24	122
September	20.7	22.6	.199825	[illegible]	24	115
October ...	[illegible]	21.4	.130000	31	[illegible]	[illegible]
November	19.3	21.0	.150922	30	24	[illegible]
December	20.7	24.1	.176760	31	24	[illegible]
Average ...	19.8		.186387	30	24	106

*Calculated on area of filter in service.

METHOD OF SUBIRRIGATION IN THE SANFORD DISTRICT, FLORIDA.

Subirrigation, although theoretically the nearly perfect method of artificial water application, has had but limited use, owing to its excessive cost. Probably the largest area of land devoted to the raising of garden crops that is watered in this way is located in the Sanford District of Florida. This district contains 1,600 to 2,000 acres of subirrigated lands, practically all of which is devoted to the growing of winter vegetable crops for use in the northern markets. The district also grows summer fodder crops for home use.

The following description of the subirrigation methods of the Sanford District is taken from a bulletin on irrigation in Florida issued recently by the U. S. Department of Agriculture. This bulletin was prepared by F. W. Stanley, irrigation engineer of the U. S. Office of Public Roads and Rural Engineering.

The soil in the Sanford District, for the most part, is of the flatwoods type, although there is some low hammock in certain localities. Much of the land away from the St. Johns River is practically level, although the general trend of the grades is toward the river. A considerable area adjacent to the river, however, has heavy grades, some of the lands falling several feet to the hundred. The grades are uniform in the latter case, the contours running about parallel to the river's edge.

The surface soils of this flatwoods type generally are light and sandy, the percentage of sand increasing with the depth until the subsoil is reached. The upper 6 or 8 in. often is rich in organic matter and dark in color, but a large percentage of the soil between the first foot and the subsoil appears to be mostly sand of a whitish or yellowish tinge. The small areas of muck or hammock lands have deeper surface soils and more organic matter throughout. The sandy soils offer very little resistance to the rapid percolation of water in times of heavy rain.

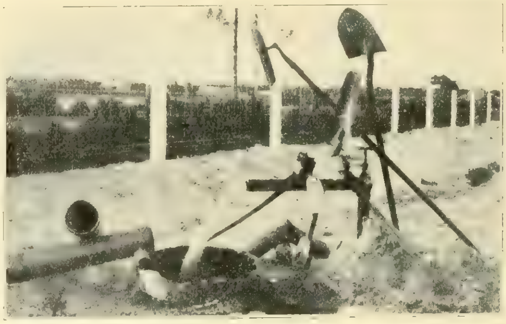
Throughout the Sanford area there is practically impervious subsoil underlying the surface at depths varying from 1 ft. to 5 ft. This impervious substratum is sometimes composed of a clay, but usually is of a sort of sandstone which appears to be cemented together with a yellowish material apparently composed of organic materials containing considerable iron, and is very hard and nearly impervious.

The water supply for irrigation use is obtained entirely from flowing wells which vary in depth from 65 to 200 ft., the shallower wells being located close to the river. It is reported that there are at least 1,000 flowing wells in this district, most of them being used wholly or partly for irrigation purposes, although a number may water private garden patches only. The cost of the wells varies with the size and depth. There are few wells in use, however, over 4 in. in diameter, while practically every farmer adopts the 2-in. size, which costs about $1 per foot complete. One well will irrigate 2 to 5 acres, depending upon the character of the soil and the flow of the well. A good 2-in. well will flow 30 to 100 gal. per minute, the better flow usually being on the lower elevations. It is a common practice for the farmer to have a number of 2-in. wells scattered over his farm rather than to attempt to get larger wells with greater capacity. Many farmers having 15 to 20 acres under cultivation will have four to seven wells, while others will make one well water 5 to 10 acres. The advantage of more wells is considerable, as rapid irrigation is especially desirable at the time of setting plants and depends upon the amount of water available.

The application of water is accomplished by the so-called subirrigation method. Briefly stated, this operation consists of running water through underground tile laid with open joints so that the water escapes at the joints and percolates through the ground, thus watering the plants in the course of time. In order to water the entire ground surface, the tiles are placed in parallel rows as close together as experiment has shown to be necessary. In the Sanford district it has been found that irrigation is accomplished to best advantage when the tiles are placed 18 to 20 ft. apart, although wider spacing is used in some cases. If the tiling is placed farther apart the irrigation will be uneven or will take too long. If the tiling is closer, the irrigation will be satisfactory, but the cost will be excessive.

The actual construction of a tile irrigation system requires considerable care and should be left to experienced hands. The following description of construction is taken from a report made to the Office of Public Roads and Rural Engineering by Milo B. Williams, irrigation engineer, who has had considerable experience in the construction of tile systems at Sanford:

The tile system consists of a water-tight main pipe feeding a series of open-jointed parallel laterals placed 16 to 18 in. below the surface. The mains are located on the highest side or on the ridges throughout the field, so that the laterals slope away from the mains at the proper depth. The mains are of 4 to 5 in. vitrified terra-cotta pipe, which is obtained in 2½-ft. lengths, with a bell end. The joints are made water-tight with cement. A stop box is placed at the intersection of each lateral with the main. Holes are cut in the side of the pipe and a short length of 2-in. steel pipe is cemented into place to form a connection between the main and the head stop box, the laterals leading out from the stop box. This metal pipe also forms a neck into which wooden plugs may be inserted to control the flow of water. Where the main feeds two laterals leading in opposite directions from the same point the stop box is placed in the main line, with the laterals leading out from opposite sides of the box.



Water Supply and Tools Used for Subirrigation.

The laterals are built of 3-in. clay draintile, which is obtained in 12-in. lengths. The pipe is laid with open joints by placing the short lengths end to end. A shovelful of sawdust or cinders is placed over each joint to prevent the fine sand from working into the line and stopping the pipe. The grades for the lateral trenches vary from a 1-in. to a 3-in. fall per 100 ft. These grades generally are obtained by turning the water into the trenches before the tile is laid, so that the digger can remove all irregularities from the bottom of the trench. The ordinary expense of the Sanford system, however, would appear to justify a more careful method of establishing and maintaining the grades. At the time the system is laid out it would be well to establish the grades of the laterals by means of a level in the hands of a competent surveyor, and they should be maintained throughout construction. Laterals are spaced 18 to 24 ft. apart, but the shorter distance has proved the more satisfactory.

Stop pockets are placed in the lateral lines at intervals of 100 to 400 ft. for the purpose of checking the water in the laterals and thus securing a small pressure in the lines above the pockets. When pockets are used for this purpose a weir division wall is inserted near the inlet side containing two metal-lined openings, one a 3-in. hole on a level with the tiles entering and leaving the box and the other a 1-in. hole about 6 in. higher. When the water is not to be held in the pipe line above a box the lower hole is left open, so that the water can pass down the line freely. When the water is to be held up the lower hole may be plugged, raising the water to the upper hole, or both may be plugged, causing the water to rise until it flows over the top of the weir wall into the next section of the lateral. The weir wall is placed nearer the inlet side of the box, making the chamber on the outlet side large enough to admit the hand easily to operate the plugs. For this purpose cypress plugs are often used. One of these consists of a large hollow plug fitted to the opening and a smaller solid plug which fits the hole in the larger plug. By this arrangement different sized streams can be obtained. The plugs often become water-soaked, making it difficult to remove them. Sliding galvanized-iron gates would be preferable.

Stop Pockets.

A mattock and ax are used for cutting the roots in the newly cleared land. A wide irrigation shovel is used for removing the topsoil and a curved adjustable shovel for cleaning out and forming the bottoms of the trenches.

The cost of the Sanford tile system ranges from $100 to $125 per acre, not including the water supply or drainage outlet from the field.

In the operation of the Sanford system water is turned into the main feed pipes and divided among a number of laterals by operating the intake plugs. The plugs in each pocket are adjusted so that the water will be backed up in certain sections and held there until the moisture meets between the tile lines. The water issues from the tile joints into the porous sandy subsoil and follows along on top of the impervious substratum until the surface-soil area is underlain with a sheet of water. If irrigation continues after this state has been reached the water will soon show on the surface.

Irrigation is begun when the first winter crops are planted in the fall. The ground is completely saturated to the surface to settle the young plants into place and give them a start. The common practice is to irrigate every 10 days to 2 weeks during the growth of the crop, depending upon the rains which occasionally occur during the winter season. Celery is irrigated 24 hours before cutting. This is thought to swell the plants and make them brighter and heavier.

The length of time required to saturate the Sanford soils varies greatly on the different farms. Some farmers use a large head from a number of wells, forcing the water into both ends of level laterals, thus causing saturation within a few hours. Others use smaller amounts of water and take 12 to 48 hours to irrigate. The amount of moisture contained in the soil prior to irrigation and the depth to hardpan determine materially the length of time necessary for saturation. It also takes longer to subirrigate a field on which a cover crop has been turned. Likewise, a soil finely pulverized is slower to irrigate than one that has not been cultivated.

Overirrigation is a common practice, and probably is more expensive than is commonly realized. On opening the tile lines to drain off the excess water large quantities of the fertilizing constituents applied in commercial fertilizers are carried away. This has taught the farmers in this section the need of applying fertilizers immediately following a heavy rain.

There are special cases about Sanford deserving of mention which have not been touched upon in the above discussion. Systems for the subirrigation of the fields adjacent to the river which have heavy grades should be laid out somewhat differently from those described above. If the mains were laid on the high side of the field and the laterals allowed to run down the slope having a grade of several feet per hundred, the water would not have sufficient opportunity to perform its task of irrigating the ground between the lines. In such a situation the main line should run down the steep slope while the lateral should lead off perpendicularly or nearly so, following approximately the contours and having a very slight grade, as in the case of the level grounds.

Instead of a main line of terra-cotta pipe some farmers use an open trough or flume, letting water into the laterals by removing wooden plugs from the side of the flume and damming the water in the flume by check gates. When this method is used water does not percolate from both sides of the tile lines but runs one way only, or down the grade from one lateral to the other. This method, while used in other parts of Florida as well as at Sanford, is not so satisfactory in very dry weather as is the subirrigation of the level lands, some of the farmers having great difficulty in getting the water to the surface.

Another special method used to some extent in Sanford is irrigation without the use of a head main feed line. In this case the lateral tiles are laid perfectly level and are fed from an open ditch which also serves as the waste or drainage ditch in times of excessive rains. This method is somewhat of a makeshift, but works very well, and can be used for a while in this form when the farmer can not afford a heavier outlay. Sometimes the farmer will use this method and lay the tiling double distance, filling in the additional lines after he has grown a crop. The double spacing does not work so well for irrigation but will answer as a temporary expedient and at the same time drain the land, which in many cases probably is of more importance than the irrigation.

The most necessary condition for successful subirrigation is a porous surface soil overlying an impervious substratum, which is the formation found in the Sanford section. The topsoil is a porous, light-colored sand, while the subsoil is a dark-colored hardpan which holds the water until it has spread laterally through the sandy topsoil. If subirrigation of high pine land with a clay subsoil 8 to 10 ft. below the surface is attempted, the chances are that water could be run in the tile a month without any appreciable effect on the surface soil. Several attempts have been made to subirrigate lands of such type near Orlando, Florida, but in every case complete failure has followed. There have been also several attempts to subirrigate the heavy clay loams of Alabama, but with most disheartening results. The causes of failure are obvious in every case when the nature of subirrigation is considered. In the attempts made near Orlando the

Water Tight Main and Stop Box.

water was lost in the depths below the surface soil and would have had to fill up all the soil above the clay substratum before surface irrigation could take place. In the Alabama installations the clay surface soils were water-logged for a distance of a foot or two on either side of the tile, the soil beyond being perfectly dry.

In the Sanford District, however, the distribution of the water is not impeded by heavy soils. There the action of the water during subirrigation has been studied carefully with the aid of a soil-sampling apparatus. These tests show that the irrigation of the surface soils is not due so much to the action of capillarity as to the simple process of filling up the soils with water. Tests taken at the time of irrigation show that the soil reaches the saturation point 6 in. under the ground surface before the surface soils are irrigated sufficiently. It also is common to find free water standing in the soils at 1-ft. depths when the plants are in need of irrigation. These tests, along with many others, show conclusively the nature of subirrigation.

It is evident that this system of irrigation requires large quantities of water, and consequently subirrigation under soil conditions similar to those at Sanford is not an economical method where the water has to be pumped. Nevertheless, it is common for the uninitiated to regard this method with favor on account of its supposed saving of water. The large quantity of water needed is no particular drawback to the Sanford farmer because the nature of the water supply assures him an unlimited quantity at no operating cost.

A comparatively even ground surface, or a uniform slope, is required for successful subirrigation. If the ground is uneven the low places will become flooded while the high knolls will not be irrigated sufficiently.

Another factor in the successful operation of a subirrigation system is the correct kind of cropping. It has been stated that the Sanford district depends almost entirely on garden products. These crops invariably are shallow-rooted, most of the plant roots feeding within 6 in. of the surface. These, being annual plants, do not have an extensive root system. It has been demonstrated in the West that the subirrigation of trees is a failure on account of the stopping up of the tile by tree roots. This is especially true if the soil is rich in plant food to the depth of the tiling. On the other hand, there are records of successful subirrigation of citrus groves through tile systems in Florida, but in such cases it is possible that the water plane stood above the tiling for long periods, thus preventing the entrance of tree roots, as the roots of most cultivated trees will not penetrate below the level of the usual water plane.

There are several groves near Terra Ceia that are subirrigated and at least one grove near Palatka. At the present time these systems are working well, and are especially valuable from a drainage standpoint. As these installations are new, it can not be determined how long they will withstand clogging by the tree roots. The subsoil surrounding the tile may be of such character as to keep roots away from the tile or the ground water may be high enough to discourage deep rooting. Still there is considerable danger of clogging if the ground water should be lowered by protracted drought or by artificial drainage on a large scale.

A common rotation of crops in the Sanford trucking district is as follows: First, lettuce is planted about Sept. 1 and harvested about the middle of October. This is followed by celery, which should be harvested by February. Cucumbers may follow immediately and should be off the ground by the first week in May. Corn then can be planted and harvested in August. There still remains enough time to grow a crop of native hay before the time to plant lettuce again.

Many of the farmers follow an entirely different schedule, although most of them plant celery. Some plant celery in October and get two crops, the last crop being harvested in July. Others plant beans, cabbage, cauliflower, and various other vegetable crops, while still others plant a considerable acreage of potatoes. The winter truck crops are shipped to the northern markets, while the corn and hay crops usually are consumed at home.

It has been stated that the cost of tiling averages $100 to $125 per acre. This would be a heavy outlay for many crops, but when the total cost of equipping land and the annual expense of growing a celery crop is considered, the cost of irrigation does not seem exorbitant since the cost of equipment, outside of irrigation, is about $450 per acre.

It should be emphasized that the Sanford subirrigation method serves also for drainage—entirely, in fact, for some crops. This is true especially for the summer cropping during the rainy season and frequently during heavy rains in the winter season. There are some disadvantages in having subirrigation and drainage systems combined, one being the large loss resulting from the draining away of expensive fertilizers; and another, the need of saturating the soil in order to get enough moisture at the surface. Even if other methods of irrigation were used, however, it would be necessary to have drainage systems installed to take care of excess water, and when it is considered that the maintenance and operation are at an absolute minimum, it may be seen that the Sanford system of irrigation is satisfactory where conditions discussed above are favorable.

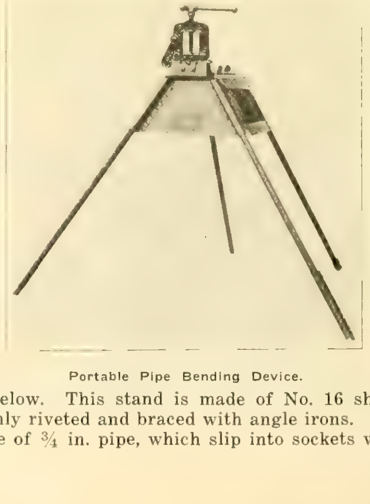
TORSIONAL STRENGTH OF NATIONAL PIPE.

The illustration shows a piece of 8-in. "National" line pipe after being subjected to a torsional stress of 712,000-in. lb. This pipe weighs in the neighborhood of 29 lb. per foot and its walls have a thickness of approximately ⅓ in.

Result of Torsional Stress of 712,000 in.-lb.

PORTABLE VISE STANDARD AND PIPE BENDER.

A portable vise standard and pipe bender that is being used by many water companies for service work is illustrated below. This stand is made of No. 16 sheet iron thoroughly riveted and braced with angle irons. The legs are made of ¾ in. pipe, which slip into sockets when the



Portable Pipe Bending Device.

stand is set up. The stand is equipped with a vise for holding pipe when cutting or threading. The bending device during these operations acts as a guide and rest for the pipe. The device will bend pipe or conduit for 1/8 in. to 3/4 in. in diameter. It weighs about 45 lbs., is easly transported and when set up is perfectly rigid. The device is manufactured by H. P. Martin & Sons, Owensboro, Ky.

COST OF CLEANING IRRIGATION DITCHES WITH A V-MACHINE.

The use of a V-machine last year for cleaning irrigation canals in the Yuma Project of the U. S. Reclamation Service not only brought about a material reduction in the cost of the work, but also resulted in the securing of a better section than could be obtained by hand cleaning. A description of this work is given by Mr. C. F. Harvey in the May Reclamation Record, from which the following notes are taken:

A V-machine was at first rented for a short time for experimental purposes, and afterwards a similar machine was built on the project at a cost of about $700. The operation of such a machine has continued since May, 1916. At first one caterpillar tractor furnished the power, but now two tractors are used. The tractors have 75 H.P. gas engines and cost $4,650 each. These tractors have proved very efficient in getting onto and over ditch banks and traveling on the banks. This equipment is used on canals carrying from 12 to 50 second-feet, and dredgers have been used for larger canals. The use of a single tractor of the above size for this work resulted in overloading the machine, and, while a heavier machine could doubtless be run without overloading, the experience on the Yuma project has been that two machines of about this horsepower are probably more efficient than one larger machine would be, as the two machines can work to great advantage in getting the V in and out of the ditches and around structures. It is to be noted, by the way, that the number of structures in a ditch greatly affects the mileage cleaned. The life of the V-machines and of tractors on this work will be about five or six years.

The following figures are taken for the month of July, 1916, when the rented V-machine was in use:

Operating, 114½ hours.
Repairs, 117½ hours.
Distance cleaned, 11.62 miles.
Distillate used, 715 gal. (one tractor).

COSTS (JULY).

Labor	$552.25
Distillate	75.07
Hauling fuel	10.33
Shop orders	5.06
Oil and waste	8.35
Supplies	18.86
Rent of V machine	175.00
Depreciation	50.00
Total	$894.92
Cost per mile cleaned	77.01

By deducting the $175 rent for the machine the cost of cleaning would be reduced proportionately. The above is for one tractor. By putting on an extra tractor the cost of fuel would be doubled, but it is thought that the mileage of canals cleaned would also be nearly doubled, while the labor cost of repairs would remain about the same. With the benefit of experience and a perfected organization it is expected that the cost can be reduced to $40 per mile. With the old organization for cleaning by shovel and teams the costs would run from $200 to $300 per mile. This was with a foreman at $3 a day and labor at $2 a day, worked in such gangs as could be retained. The organization worked with the machine equipment at present is as follows:

1 foreman at $4.50 per day.

Crew of V-machine:	Crew of caterpillar:
1 man at $3 per day.	1 operator at $5 per day.
1 man at $2.50 per day	1 oiler at $2.50 per day.

There are on the Yuma project more than 200 miles of ditches to be cleaned of a size suitable for the economical use of the V-machine. This makes it possible to keep the equipment in operation for 12 months a year. The amount of work to be done is, of course, an important consideration in making the expenditure for the tractors.

A MUNICIPAL WATERWORKS CONSTRUCTED AND OPERATED SOLELY FOR INDUSTRIAL SERVICE.

The city of Mattoon, Ill., is one of the few municipalities in this country that operates a system of waterworks solely for commercial purposes. The installation was describel by Mr. C. C. James, superintendent of the plant, in a paper presented at the recent meeting of the Illinois Section of the American Waterworks Association, from which the following notes are taken:

The water for domestic uses and fire protection is furnished by a private corporation, the supply being taken from the glacial drift at a depth of about 60 ft. For purity and wholesomeness the water furnished by the private corporation is seldom excelled. The quantity that could be obtained from this source, however, was found to be insufficient to supply the needs of the city for both domestic and commercial purposes.

In order to have a sufficient amount of water to supply all demands of the railroads and other large consumers, the citizens of Mattoon early in 1907 organized a stock company for the purpose of constructing a waterworks system with a capacity large enough to guarantee a sufficient quantity of water to meet all demands made by the railroads, factories and other large consumers.

The capital stock of $105,000 was fully subscribed by the citizens of Mattoon after a canvass of less than ten days' duration. Before the work of construction was begun the City of Mattoon entered into a contract with the Mattoon Reservoir Co., agreeing to purchase the system after its completion and the Reservoir Co. agreed to sell the plant to the city at the actual cost of construction, plus 5 per cent interest. This agreement was carried out in full by both parties, and the City of Mattoon finished paying for the plant in four years' time.

After the plant was fully completed a certified bill of cost was made, setting out in detail the exact cost of the entire system, including all dams, reservoirs, lands, engineering and supervision of construction. The total cost of the system, including the lands, was $103,000. This amount completed the dams, reservoirs, purchased and installed the pumping machinery and built two pumping stations, installed suction pipe, intakes and about 5 miles or more force mains between the reservoir pumping station and the main station.

The water is pumped from Paradice reservoir to the service reservoir by a 6-in. single-stage centrifugal pump direct connected to a 50 H. P. electric motor. The electric current is obtained from the local public service company, the maximum charge being 2.35 ct. per K. W., with an average charge of 1.9 ct. per K. W. The average cost of current used in pumping 1,000 gal. against a total head of 130 ft. is 1.2 ct. The water rate ranges from 4 ct. per 1,000 gal. where monthly consumption exceeds 16,000,000 gal. to 12 ct. per 1,000 gal. where consumption does not exceed 100,000 gal. per month.

The plant is managed by a board of four members, and usually comprises the most capable citizens. By the ordinance creating the board no city official is allowed to become a member except the Mayor, who is ex-officio chairman. The citizens of Mattoon are very proud of this water system, especially those who participated in financing the original proposition. The Water Department now has a sinking fund containing about $35,000 derived solely from the profits accruing from the operation of the waterworks system. In addition to this, betterments and improvements have been made since 1908 amounting to about $30,000, all being paid from the earnings of the plant.

FILTRATION PLANTS IN UNITED STATES AND CANADA.

Statistics compiled by Burns & McDonnell, consulting engineers, Kansas City, Mo., show that over 19,500,000 people in the United States and Canada are now using filtered water. In 1900 less than 2,000,000 people were so supplied. Ten years later the number had increased to 10,000,000, and at the present date approximately 20,000,000 people are using filtered water. In 1900, 50 cities had filtration systems and in 1917, 781 cities were thus equipped, an increase of nearly 700 per cent.

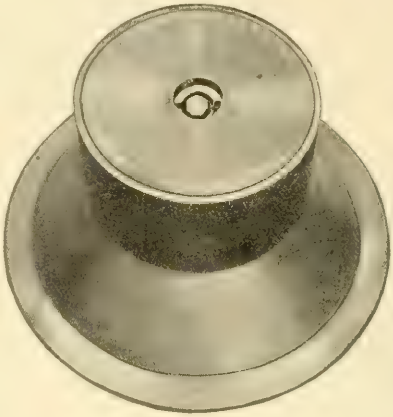
Reliable data pertaining to typhoid show that the death rate has decreased at about the same proportion as the use of filtered water has increased. This in itself is sufficient reason why filtration plants are being installed in many municipalities. Along with the growth of filtration systems there also has been a marked improvement in the design and economy of operation. For example, 18 years ago when Burns & McDonnell designed filtration plants they felt that they were getting fairly good results when they obtained an average bacteria removal of 96 per cent. Now tests are looked upon with some suspicion unless a bacteria removal of over 99 per cent is secured. In filtration plants designed 15 to 18 years ago it was not unusual to use as high as 6 per cent of the filtered water for washing purposes and cleaning the filters. Some recent tests show that the amount of wash water now used with the more modern methods hardly ever exceed 1 per cent. This has made it possible for many smaller cities to operate efficiently and economically mechanical filter system and procure an absolutely safe and pure water at all times.

The following table, compiled from data prepared by Burns & McDonnell, shows the number of filtration plants and population served in the United States and Canada:

State.	Municipal owned.	Private owned.	U. S. owned.	Total plants.	Population covered.	Total filter capacity.
Alabama	6	5	..	11	250,000	27,025,000
Arizona	..	1	..	1	[illegible]	300,000
Arkansas	3	6	..	9	103,000	14,100,000
California	5	12	1	18	1,168,000	36,463,000
District of Columbia	1	...	..	1	353,000	75,000,000
Colorado	6	3	..	9	271,000	62,475,000
Connecticut	3	3	..	6	175,000	31,000,000
Delaware	1	...	..	1	92,000	24,000,000
Florida	1	...	..	1	3,000	....
Georgia	26	2	..	28	345,000	64,350,000
Iowa	11	10	..	21	276,000	53,700,000
Indiana	5	14	..	19	553,000	92,950,000
Illinois	15	21	2	38	481,000	112,050,000
Kansas	29	4	1	34	218,000	42,726,000
Kentucky	7	11	..	18	379,000	108,750,000
Louisiana	3	1	..	4	406,000	52,500,000
Maine	2	8	..	10	86,000	22,550,000
Maryland	5	5	..	10	631,000	141,850,000
Massachusetts	10	2	..	12	368,000	44,800,000
Michigan	4	5	..	9	255,000	54,410,000
Minnesota	8	3	..	11	380,000	62,928,000
Missouri	16	15	..	31	1,021,000	203,432,000
Mississippi	4	1	..	5	83,000	14,300,000
Montana	6			6	35,000	22,800,000
New Jersey	13	19	..	32	339,000	165,194,000
New York	41	20	2	63	2,859,000	198,194,000
Nebraska	1	1	..	2	6,000	600,000
New Hampshire	2	4	..	6	51,000	6,614,000
New Mexico	2	1	..	3	6,000	1,500,000
North Dakota	6	...	..	6	42,000	8,836,000
North Carolina	32	7	1	40	315,000	47,455,000
Ohio	40	10	..	50	2,025,000	510,055,000
Oklahoma	28	..	..	28	266,000	45,720,000
Oregon	5	5	..	10	33,000	12,618,000
Pennsylvania	19	80	..	99	3,436,000	860,361,000
Rhode Island	1	[illegible]	..	16	316,000	33,000,000
South Carolina	9	6	..	15	172,000	27,400,000
South Dakota	1	2		3	24,000	1,850,000
Tennessee	5	3		8	125,000	23,500,000
Texas	16	3		19	378,000	42,120,000
Vermont	1	2		[illegible]	50,000	4,570,000
Virginia	7	6	1	14	205,000	29,150,000
Washington	2	..		2	8,000	[illegible]
West Virginia	7	6		13	122,000	[illegible]
Wisconsin	[illegible]	5		1	176,000	[illegible]
Wyoming		1		1	12,000	6,117,000
Canada						
Alberta	[illegible]	...	..	3	62,000	12,000,000
Manitoba	1	2	..	3	16,000	4,350,000
New Brunswick	1			1	7,000	2,000,000
Saskatchewan	1			[illegible]	40,000	16,400,000
Quebec	10	7		17	[illegible]	166,250,000
Totals	[illegible]	[illegible]	8	781	[illegible]	3,659,771,000

METER BOX FOR OUTSIDE SETTINGS.

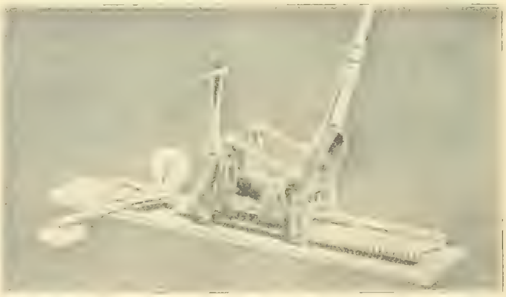
The accompanying illustration shows a meter box designed especially for outside settings in cold climates where it is necessary to protect the meter from freezing. The box is placed on a base of tile pipe or concrete where pipes are laid at a depth requiring it. The outside cover is provided with an ingenious device for locking which protects against interference by unauthorized persons and at the same time provides easy lifting against frost resistance. This box also is adaptable for use in warm climates where pipes are laid at shallow depths and where the inside cover is not necessary. It likewise can be used for housing valves, service cocks and other apparatus which are placed underground. It provides an enclosure large enough to permit accessibility for repairs and inspection. This meter box is known as the "Jersey." It is manufactured by the S. E. T. Valve & Hydrant Co., Inc., 50 Church St., New York.



The "Jersey" Meter Box.

PIPE PUSHING DEVICE.

A device for pushing pipe under streets and lawns, thus eliminating the cutting of the surface, is now being employed by many water works operators and contractors. The use of the device saves 75 to 85 per cent of the trenching that would be required if the pipe was placed in the ordinary way. The machine illustrated works upon the cog-drive principle and it is claimed that its double compound leverage enables one man to exert a push of over 4 tons. The arrangement is furnished with an improved steel pilot which is stated to run straight under any reasonable conditions and will work any place a spade will dig. The device described is known as the Easy Pipe Pusher. It is manufactured by the Easy Manufacturing Co., David City, Neb.



Device for Pushing Pipe Under Streets, Lawns, Etc.

PERSONALS.

E. B. Bradbury, Consulting Engineer, Columbus, O., has been appointed Sanitary Engineer of Franklin County, Ohio.

Dr. W. F. M. Goss has been elected President of the Railway Car Manufacturers' Association, with offices at 61 Broadway, New York City. Dr. Goss formerly was dean of the College of Engineering of the University of Illinois.

Jay A. Craven, Assistant Manager, Terre Haute, Ind., Water Co., has been named by the State Board of Health of Indiana as member of the Board of Sanitary Commissioners of Indianapolis, which will have charge of the construction of a sewage disposal plant for the city.

Gaylord C. Cummin, for the past two years City Manager of Jackson, Mich., has been appointed City Manager of Grand Rapids, Mich., at a salary of $10,000 a year. Mr. Cummin formerly was city engineer of Dayton, O. When the Commission Manager plan was adopted by Jackson, he was called there at a salary of $5,000, which was subsequently increased to $6,000.

M. W. Watson, Assistant Road Engineer of Illinois State Highway Department, has resigned, effective May 7, to accept the position of Road Engineer with the Kansas State Highway Commission. Previous to his employment with the Illinois Highway Department he served with the U. S. Engineers' Office at Louisville, Ky., on the Ohio River Improvement and on various engineering work in Ohio, West Virginia, Indiana and Kentucky.

Dirt Mover and Pit Owner Issue
of

Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

First Wednesday Each Month............Roads and Streets......$1 Yearly
Second Wednesday Each Month, Waterworks and Hydraulics.......$1 Yearly
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STATE OWNED RAILWAYS AN ECONOMIC FAILURE.

About ten years ago William Jennings Bryan made a few weeks' "triumphal tour" of Europe and upon his return announced that he had been convinced that America could profit by the example of European countries that owned railway systems. Nothing that a statesman could do to discredit himself in the estimation of thinking men could have been more effective than this utterance; for a thinking man knows that a complex economic problem is not to be solved by a few weeks of sight-seeing and listening to special pleading.

State owned railways have been noteworthy for their lack of progress—a defect characteristic also of state owned telephone and telegraph systems. This alone should suffice to make any one chary about advocating public operation of most public utilities. Even granting that as low unit prices were to be had under state as under private ownership at any given time, this would not be the final criterion. The essential question is: Under which administration do the unit costs show the most rapid relative decline? Note that we do not say unit prices but unit costs, for a government often charges prices that are below actual costs (inclusive of interest and depreciation) and makes up the deficit by taxation. Under public commission rate regulation, the cost becomes the base for rate making.

The evidence is steadily piling up to prove that not only is economic progress virtually suspended under government ownership of railways but that ton-mile prices are both actually and relatively higher than under private administration. Faced by such facts every socialistic theorist of "what ought to be" should halt and scan "what is." Deductive reasoning from any hypothesis may be correct as far as the reasoning process itself is concerned, but if the final inference fails to accord with the facts, it is clear that the hypothesis was in error. Socialists rarely seek data by which thus to test their hypothesis that the state can save the huge profits of individuals and thus give the average man a greater share of the products. Socialists assume this to be self-evident, and they are not the only ones who do so.

Quite recently Josephus Daniels, Secretary of the Navy, speaking in defense of government-built battleships, said:

[illegible]

Note the tacit inference that a profit is something that has no equivalent in the cost incurred by a government. Yes, a profit can be eliminated, but what steps into its shoes? The socialistically inclined seldom stop to answer this question. In the place of private profit—which for the most part is a combination of managerial salary and a bonus for competence—there enters a whole battalion of government costs, not the least of which is the cost of not progressing to lower costs through inventiveness inspired by a desire for profit.

Mr. W. M. Acworth, one of the foremost economists of England, recently came to America. One of the press reports of his testimony before a congressional committee bears directly upon the subject of this editorial, so we quote it in full:

[illegible] interstate commerce, of which Senator Newlands is chairman, W. M. Acworth, England's leading railroad authority, appeared here to discuss the question of government ownership of railroads in foreign countries. Mr. Acworth has just completed his work as one of the Royal High Commission which recently investigated the railroad situation in Canada.

Mr. Acworth dwelt first with Prussia, which he regarded as the best example of an efficient nationalized railway system. Following the war of 1870, which unified Germany under the leadership of Prussia, Bismarck attempted to acquire all the railways of Germany in order to weld the newly formed empire into one unit.

In 1879 the ministry submitted to the Prussian parliament an elaborate memorandum in support of the policy of nationalizing the railroads then in private hands. The significant feature of this memorandum, said Mr. Acworth, was the emphasis placed upon the importance of railways for military purposes.

"On the whole," said he, "it is abundantly clear that the main reason for Bismarck's action was of a political nature. It is in harmony with all Prussian history that the importance of military considerations and the necessity of making public control paramount in the life of the country should weigh above all other considerations with a Prussian statesman; and after the war with France and the creation of the German Empire these considerations might be expected to have even greater weight than at any other time."

Citing Prof. Schumacher of Bonn, Mr. Acworth said that the freight receipts per ton mile in 1880 and in 1909 in Germany were respectively 1.65 and 1.41 cents. The corresponding receipts per ton mile for American railways were, in 1882, 1.23 cents, and in 1909, 0.763 cent. In other words, the American ton-mile rate started at the beginning of the period 25 per cent below the Prussian rate, and it fell in the course of the twenty-nine years not 15 per cent, but nearly 40 per cent. At the end of that period the American rate was not much more than one-half the Prussian rate—0.763 cent, compared with 1.41 cents. The witness added that progressive rate reductions in Germany had ceased long before 1909.

"While American companies have revolutionized their equipment and methods of operation," said the witness, "Prussia has clung to the old equipment and old methods. This is typical," said Mr. Acworth. "In all the history of railway development it has been the private companies that have led the way, the state systems that have brought up the rear.

"The state official mistrusts ideas, pours cold water on new inventions, and grudges new expenditure. In practical operation German railway officials have taught the railway world nothing. It would be difficult to point to a single important invention or improvement the introduction of which the world owes to a state railway.

"That Prussia was the only country where the state system shows a profit after payment of operating expenses and interest on capital," said Mr. Acworth, "followed because Prussia bought the railroads at a most opportune moment, and has been powerful enough to maintain a scale of rates unaltered over a long period of years."

A THOUSAND YARDS OF LIMESTONE LOADED PER SHIFT BY A STEAM SHOVEL.

In excavating the Chicago Main Drainage Canal 20 odd years ago steam shovels were not much used for loading the blasted rock, which was a limestone that broke out in rather large chunks. The best shovel record for a 10-hour shift's work in this rock was made by a Bucyrus 55-ton shovel with a $2\frac{1}{4}$-yd. dipper, and it was 600 cu. yd. of solid rock. But the same shovel working two 10-hour shifts daily for four months averaged 14,700 cu. yd. a month, or 7,350 cu. yd. for month of single shift work. This was equivalent to slightly less than 300 cu. yd. per 10-hour day. (See Gillette's Handbook of Rock Excavation, p. 669.)

Last year, working in the same limestone, a steam shovel averaged 26,000 cu. yd. per month of single-shift work, or better than 1,000 cu. yd. per 10-hour shift. This is more than three times the daily output of a shovel 21 years previously. What is the reason for this marked improvement?

Shovel design has been greatly improved, for one thing, but it is to the use of much larger shovels that we must look for the major part of the increase in daily output. A Marion shovel (model 251) weighing 175 tons and equipped with a 3½-yd. dipper, made the output of 26,000 cu. yd. a month, in Section 9 of the Calumet Sag Channel, under the management of Byrne Bros.' Dredging and Engineering Co. of Chicago. The shovel crew was 4 men, inclusive of pit gang. The same shovel working in glacial drift averaged 2,300 cu. yd. per 10-hour shift.

These large outputs are only obtainable where a shovel does not have to wait for cars. In this case the cars were of 7-yd. capacity, two in number, hoisted by an engine up an incline and automatically dumped from a Page tipple. One car makes the round trip while the other is being loaded, the round trip of 350 ft. being made in a minute. A detail design of a somewhat smaller tipple is given in Gillette's "Earthwork and Its Cost." The tipple, which was operated by four men, was designed by the Page Engineering Co. of Chicago.

The drilling of the limestone was done with two Ingersoll-Rand traction drills (see Gillette's "Handbook of Rock Excavation," p. 141), which drilled 3-in. holes, 17 ft. deep or 2 ft. below grade. The holes were spaced 5x7 ft., and each hole loaded with 12 lb. of 40 per cent dynamite. Each drill was operated by a driller, a fireman and two helpers. Note particularly that the large traction or wagon-mounted drill, has effected quite as remarkable an increase in footage drilled as the large steam shovel has effected in yardage loaded. Each of these traction drills break 13,000 cu. yd. of solid rock per month, the holes being very closely spaced (5x7 ft.). In a subsequent issue we shall have more to say about this drilling performance, for it is so noteworthy as to merit special discussion.

The entire combination of traction drills, large shovel and incline tipple, is one that may well arrest the attention of any one having rock excavation to do on a large scale and under conditions that make such a combination feasible.

INORDINATELY HIGH COST OF MUNICIPAL STABLE ATTENDANTS, AND HAULAGE, AND HOW TO REDUCE IT.

In our issue of May 2 we published an editorial entitled "City Horses That Have More Servants Than City Men," in which we criticized the garbage collecting department of the city of Columbus for expending 29 cts. a day per horse for stable attendants. Mr. E. W. Stribling, Superintendent of the Department of Public Service of Columbus, has replied to our criticism in a letter which we publish in full in another column. We ask our subscribers who are interested in public economy to read Mr. Stribling's letter, to a criticism of which we now pass.

The contention is made that 29 cts. a day is a low cost for feeding, grooming and attending a horse, and this claim is based on the ground that it costs other cities even more than 29 cts. per day per animal for stable attendants. But note particularly that Mr. Stribling does not compare this unit cost with that incurred by companies and private individuals in Columbus and elsewhere. Note also that Mr. Stribling excuses the extravagant cost largely on the ground that only an 8-hour shift can be worked, which "makes necessary the dividing of each day into three periods of eight hours each." Then this excuse is made the reason for having two shifts of eight stable attendants in each shift and one night watchman to care for 142 horses!

Mr. Stribling winds up with this request:

> As your paper seems to know what ought to be done I would [illegible] the assistance of your editorial and reporter staff in solving the question of how best to collect garbage and refuse with the least expense.

Very well, we accept the challenge implied. The editor of Engineering and Contracting has owned and maintained hundreds of horses and mules, and at the present writing has 24 head of stock engaged on construction work. He should therefore be able to "qualify as a witness."

An eight-hour law does not make necessary three or even two daily shifts of stable attendants. A horse requires about 50 lb. of hay, grain, etc., daily. In a stable of 142 horses this means the handling of about 3½ tons of fodder daily. To perform this service are 16 men required, working in two shifts of eight hours! And when 16 men and a night watchman work thus, can it be truly said that "each man takes care of a fraction less than 18 horses each day"? Mr. Stribling's attempt thus to refute our statement that for every eight horses there is one attendant is curious. No manipulating of the figures can alter the fact that during every 24 hours the service of 17 men is required for 142 horses in the Columbus garbage department, or about eight horses per man.

For this stable of 142 horses there are about seven tons of fodder and manure to be handled every 24 hours. Yet Mr. Stribling's letter seems to imply that a very large task is involved in this item alone; for he speaks of eight men being engaged five hours in "cleaning the stable, loading manure cars and unloading feed." But this poor showing is made doubly poor by the fact that eight more men (the afternoon shift) are required to do "almost the same work as the morning shift except that they spend a larger percentage of their time in cleaning and doctoring the horses"!

We come now to our promise, that we would suggest how to reduce the cost of garbage collection in Columbus, O. Our first step would be to sell the entire stable of 142 horses and release the 17 attendants as well as the horses for farm work. Coincidentally we would substitute motor trucks and trailers for the hauling of garbage. Our next step would be to pay the operators of these motor trucks and the garbage collectors a bonus per ton and per ton-mile of garbage handled in excess of a stipulated minimum. Our third step would be to employ a civil engineer as a cost accountant, inspector and critic, entirely independent of the staff engaged in operating the garbage collection, and reporting direct to the mayor of the city and not to the Superintendent of Public Service.

With this last change established there would never occur a self complacency in the garbage department not warranted by really low unit costs.

We are aware that the Columbus costs are lower than in many American cities, but that in itself is no ground for much satisfaction. Let Mr. Stribling go to any department store or large industrial establishment in Columbus where horses are used, and ascertain the daily costs of stable attendance, etc., if he would secure some really worth while standards of unit costs by which to judge the performance of his own department.

In our issue of Nov. 13, 1907, we published statistics showing that it was costing the street cleaning department of Boston $43 per month for each of 128 horses for rent, repairs, shoeing, veterinary services, medicine and feed. At the same time it was costing the firm of S. S. Pierce & Co., wholesale grocers of Boston, less than $28 per horse per month inclusive of the cost of boarding the horses in a public stable; and individuals who owned their own stables were paying only $19 per horse per month for horse maintenance.

In our issue of May 20, 1908, we published a report by The Parsons-Hering-Whinnery Commission showing that the New York City street cleaning department was maintaining 1,174 horses at $1.30 a day, as compared with less than $1 paid by private corporations. The stable attendance was costing New York City 20 cts. per horse per day (hostlers receiving $720 a year), which was regarded as extravagant. The stablemen in Columbus are paid $840 a year.

In Gillette's "Handbook of Cost Data," an abstract of the above is given, and it is stated that in the city of Providence, R. I., one stableman cares for and harnesses 16 horses. It is so generally known that one man can care for at least 16 to 20 city horses, handling feed, manure, etc., that the Columbus garbage department is without any real excuse for employing 16 stablemen for 142 horses.

Prior to the installation of motor trucks, the stable force should be cut in two, for it could then do the entire work. Let no talk about two or three shifts of eight hours a day be used to conceal the real fact that the total number of horses divided by the total number of stable attendants gives the number of horses per man by which to judge hostler efficiency.

In construction work the editor requires one stable attendant to care for not fewer than 24 head of stock, but in city work it is not to be expected that so high a ratio can be secured.

In our issue of July 16, 1913, we printed data showing that the city of Boston was paying 53 cts. a day per horse for stable attendance for 154 horses; and we criticised severely such an outrageous expense. High as that is, there have been worse records. In our issue of April 23, 1913, it was shown that in the federal government printing office department it was costing $1.25 a day per horse for stable attendance alone, or more than four times what it is costing Columbus! Incidentally, we may add, the federal printing office substituted motor trucks for horses.

Let no superintendent of a city department congratulate himself too heartily because some other cities, or even all other cities, have not equalled the economic performance of his department. Let him, rather, seek corresponding unit costs that private individuals and companies are incurring and use them as standards of comparison. Let him strive to secure authority for paying bonuses to his men for output in excess of a given daily standard.

If this were universally done we unhesitatingly say that half the city employes in America could be relieved of their present duties, or all could be retained and required to render double the service now rendered.

THE FIRST BOOK ON CLEARING AND GRUBBING.

It is a singular fact that vast sums of money may be annually expended on a given class of work yet with no book as a guide to the wisest expenditure. Until "Earthwork and Its Cost," by Halbert P. Gillette, was published fourteen years ago there was no book devoted to the economics of earth excavation and embankment. The same author has just produced a book entitled "Handbook of Clearing and Grubbing Methods and Cost" (published by Clark Book Co., 27 William St., New York City, price $2.50), which is the first book on the subject of removing trees and stumps.

In the preface to the book it is estimated by the author that fully two billions of dollars have been expended in America in clearing farm lands. Certainly the sum would be huge enough were it a substantial fraction of this estimated amount—enough, one would think, to have led some one to write a treatise on land clearing long ago. Several bulletins, it is true, have been isued by the U. S. Department and by State Agricultural Experiment Stations, but none of them even claimed the dignity of being a book on clearing and stumping.

In 240 pages, including 67 illustrations, this new book presents an epitome of all the previously published experience on the subject, a goodly part of which had already appeared in the columns of Engineering and Contracting during the past 11 years. When thus brought together in classified form, the information on clearing and grubbing is seen to be very extensive and varied. Gaps there are, it is true, and much yet remains to be written on the gentle art of separating a tree from the soil; but it is noteworthy that "Clearing and Grubbing" contains as many pages as did "Earthwork and Its Cost," written in 1903.

Incidentally it may be of interest to add that the publishers announce as almost ready a new edition of the "Earthwork," to be issued in two volumes of more than 800 pages each, containing eight times as much text as the old edition.

Last fall (Oct. 18) we reviewed Gillette's "Handbook of Rock Excavation Methods and Cost," which has grown to 840 pages, exclusive of tunneling. A separate book on the tunneling of rock and earth is in preparation. These four reference books—two now in print and two nearly ready for the printer—cover the field of "dirt moving" with great thoroughness. Yet not a month passes (as this very issue of "E. & C." testifies) that valuable additions to our knowledge of excavating and handling earth and rock are not made.

That "dirt mover" that thinks he has learned it all, and need read no more about digging "dirt," has begun the digging of his own intellectual grave. We do not stand still a day in this country in the development of economic methods and machines. Nevertheless it is equally true that very much of what was published 20 or more years ago is still applicable. Hence the constant need of reading both books and current periodicals, the former to get the summaries of the best past practice, the latter to get the up-to-the-minute hint, method or device.

THE USE OF GASOLINE ENGINES ON A DRAG-LINE EXCAVATOR.

On the Pacific coast, where coal is unusually high priced, gasoline engines are extensively used in place of steam engines for almost every kind of work. For large engines it is customary to use a cheap grade of "oil" called distillate, the price of which has been as low as 5 ct. per gallon and seldom exceeds 10 ct. per gallon even in rather inaccessible places.

For an engine that is running continuously at full capacity about one pint of distillate is consumed per horsepower per hour; but on most kinds of construction work an engine does not run continuously at full load. For example, the Excavating Engineer for May states that a class 14 Bucyrus drag-line equipped with a 120 H.P. six cylinder gasoline engine uses 6½ gal. of distillate per hour "when running steadily." This is 52 pints an hour, or less than half the consumption that would be required for a 120 H.P. engine running continuously at full capacity.

Incidentally, it may be added, this same drag-line, equipped with a 2-yd. bucket on a 60-ft. boom, is averaging about 1,000 cu. yd. of silt in 8 hours digging a drainage ditch on the Yuma reclamation project in Arizona. "When the drag-line is started in the morning the engine runs on gasoline for several minutes until warmed up; and then the distillate is switched on." The distillate costs 9 ct. per gal. at Yuma.

Any steam engine operator soon becomes familiar with the use of a gasoline engine, and usually comes to prefer it to a steam engine. The firemen necessary on a large steam engine is dispensed with. No time is lost in starting in the morning. The problem of hauling fuel is greatly simplified, and other advantages accrue from the use of "liquid fuel."

EDITORIAL COMMENT.

Frank Trumbull, chairman of the Railway Executives' Advisory Committee, in a recent lecture to the students of the University of Pennsylvania, cited many specific instances of great saving in railway maintenance and operation brought about by the adoption of accurate methods of cost keeping. The educational campaign that Engineering and Contracting began more than eleven years ago for the more extensive use of unit cost keeping in construction and railway work has borne useful fruit, yet the harvest has scarcely begun to be gathered.

Contractors with teams or traction engines should be able to contract for farm plowing, hauling, etc., to good advantage. A hint to those contracting for plowing: Use a gang plow with at least six head of stock to a plow, and drive them with a jerk line.

A trick worth remembering where a 4-horse snatch-team is required is this: Hitch the four horses abreast, and mount the eveners on steel runners. This 4-up team can be readily handled and speedily hooked on to a load, and the eveners are not worn out from dragging in the dirt.

COST OF MAINTAINING CITY HORSES.

To the Editor: In your issue of May 2 there appears an article on page 405 under the heading "City Horses That Have More Servants Than City Men." As this article relates to the stable operated by this department it is interesting to us. We cannot understand how a journal that has the reputation that yours has could publish an article criticizing the management of any firm, institution or corporation without first having made a thorough investigation to determine whether you have analyzed the figures correctly. The substance of your article convinces me that the writer of same has either unintentionally misrepresented the conditions existing in the stable managed by this department or that he is a man who writes without regard for the truthfulness of his articles.

For the enlightment of the author I furnish the following information. The City of Columbus is prohibited by ordinance from the working of any employe for a longer period than eight out of each 24 hours. This regulation makes necessary the dividing of each day into three periods of eight hours each. We have 17 men employed in the stable, 16 care for the horses and one man acts as night watchman. Of the 16 stablemen, eight commence work at 3:30 a. m. and quit at 11:30 a. m. This crew is employed on what we call the morning shift. They must have all horses watered, fed and cleaned ready to be taken out by the drivers at 6:30 a. m. From 6:30 a. m. to 11:30 a. m. they are employed cleaning the stable, loading manure cars and unloading feed. The average number of horses cared for by this shift in 1916 was 142 each day. If your mathematician will revise his figures he will find that each man takes care of a fraction less than 18 horses each day. I consider that number of horses a fair day's work for any man. Eight men are employed on the afternoon shift commencing work at 11:30 a. m. and quitting at 7:30 p. m. This shift does almost the same work as the morning shift except that they spend a larger per cent of their time in cleaning and doctoring the horses. Each man on this shift takes care of 18 horses. The night watchman commences work at 7:30 p. m. and quits at 3:30 a. m. I suppose that even a private corporation or contractor would consider it necessary to have a night watchman employed to look after 142 horses, buildings, equipment and feed worth about $200,000. The stablemen employed are not paid $100 a month but $70.00. The cost of labor per horse each day is, as you state, almost 29 cts. a day. The cost, however, is divided as follows: Morning shift, 13.6 cts.; afternoon shift, 13.6 cts.; watchman, 1.8 cts.

In conclusion I would like your valuable paper to advise me as to how this cost can be lowered with the conditions existing as I have stated.

This department has been commended by nearly every well known municipal paper in the country and our costs on garbage collection are generally recognized as lower than most cities, but we are always glad to be advised on how to improve our service and lower our cost. As your paper seems to know what ought to be done I would appreciate the assistance of your editorial and reporter staff in solving the question of how best to collect garbage and refuse with the least expense.

E. W. Stribling,
Superintendent Department of Public Service.
Columbus, O.

The total excavation on the Panama Canal during the month of March amounted to 1,097,000 cu. yd. Of this 73,560 cu. yd. of earth and 685,550 cu. yd. of rock were removed from the Gaillard Cut.

The citizens of Arizona will vote at the next general election on a law to restore the contract system on state construction work. A bill to this effect was passed by the legislature and signed by the governor, and must now be approved by the electors. The contract system on state work was abolished by the Industrial Pursuits Act of 1914.

GRAVEL DEPOSITS: THEIR ORIGIN AND ECONOMIC DEVEOLPMENT.

Contributed by Wm. Artingstall, Consulting Engineer, Chicago.

A gravel deposit is in a class by itself. Each deposit must be examined, analyzed, and made to stand on its own merits. All have certain characteristics that serve to identify them and deposits in the same field have some features in common, although at times the relation can hardly be recognized and only a critical study will determine the nature of the deposit and its value.

In order to understand the gravel deposits scattered throughout the United States, it is necessary to be more or less familiar with the nature of the deposit, the reason for it being where it is, and the characteristics of the particular deposit under consideration or of similar ones. The subject is the history of geological formation, the erosion by rivers and ice with subsequent sedimentation and the transportation of the material by various agents to its present resting place.

Although beds of gravel are found in the formation of every geologic age, either as regular or as limited deposits, those of recent formation are generally "loose gravel" while the older formations are usually found as a conglomerate, cemented together by some infiltrated current such as iron, lime, or silox. This, however, is not always the case, for even in deposits of the Glacial Period there is found extraordinarily tough conglomerate such as was encountered during the construction of the Chicago Drainage Canal.

While, as previously stated, gravel is found in various geologic formations, the greatest percentage of economic areas are of glacial origin. In many regions these areas are found in the moraines that mark the period of hesitation or the recession of the glacier, which was the transporting medium. In other localities the deposits have been laid down by other agents.

The marginal and terminal moraines identify the limits of the glaciers that pushed their way down from the north carrying a vast amount of material as they advanced and depositing the burden as the ice receded. The medial and marginal, or lateral moraines are composed of material varying from fine sand to boulders with more or less till; but the terminal moraine is composed of sand and gravel, from fine to large boulders, with many heavy knolls or ridges of till.

The Pleistocene gravels are divided into two classes—the "high," which are generally the more ancient, having been deposited subsequent to the formation of the present valleys, and the "low gravels" produced by the present rivers. The deposit may be found in the bed of an ancient river, more or less distant from the existing stream, or may form the banks or sides of a valley cut by the existing river as it flowed through the deposit. In many cases terraces identify the river bed at successive stages and tests of banks or cuts will often give a fair idea of the value of the deposit.

The deposits formed by sedimentation, while of less magnitude than the morainic deposits, are by no means unimportant. They are much sought and generally worked, because they are generally found to make a much cleaner pit than one situated in a moraine, especially if the latter was not washed by post glacial waters. Many of the deposits located in Illinois, Indiana, and in the west central States are sedimentary.

The flood plains of the mountainous regions are generally coarse gravel deposits built up in prehistoric times and then partly cut away by the streams flowing across them. What became of the vast amount of eroded material is shown by the gravelly bars and reaches in the river or by the banks of gravel sometimes miles and miles below the origin. Deposits formed by sedimentation in either the pre-glacial or post-glacial rivers are generally rich in gravel, although, in most cases, the assortment of sizes is limited in any particular locality or region. Where the gradient was small, only the smaller sizes will be found in the lower reaches; but where the steep gradient prevailed the coarse material was carried considerable distance down the river.

Along the Illinois River, just below the Marseilles moraine, the deposits are almost entirely of gravel—very little sand being found. Much of the gravel is too coarse for ordinary use, but the sand found is sharp and angular. Farther down the river the deposits are extensively developed for commercial purposes. The deposits in the vicinity of Glen Falls and Sandy Hill, New York, are delta deposits of the Hudson River formed during the last stages of the Glacial Period; while those in Saratoga County were formed some time earlier, as is evidenced by the line of eskers or gravelly ridges. The stratified deposits of sand and gravel lying along the Allegany River, near Allegany, N. Y., within the terminal moraine, were formed by a river flowing under the glacier. But the stratified deposits along the course of the middle Illinois River are flood plains of the original river, as are the many similar deposits along the valleys in several of the central States, while the deposits near Summit, Ill., identifies the "Calumet Beach" of Lake Chicago.

The deposits in the valley of the Fox, the Du Page, Kankakee, and Desplaines Rivers are all of glacial origin, and, while lying within the morainal area, many have the character of out-wash material. They are nearly free from clay and are stratified with sand. Another heavy deposit of morainic gravel is found near the west end of Lake Geneva, Wisconsin; and deposits of the same character are found in the vicinity of Minneapolis, Minn. Many of the latter are of very little value on account of the numerous clay knolls and ridges that prevent economical development on a large scale; but the scarcity of good material, within a reasonable distance, and the active demand, has created a market for what would ordinarily be considered very poor sand and gravel.

This condition has been taken advantage of by a dozen or more small operators, each working a small pit of 20 to 50 yd. capacity, utilizing the crudest kind of machinery and disposing of everything that falls on the belt. Whether it be stripping, sand, or small stones, it is all classed as gravel. Fortunately, their output is taken by small builders, which leaves the product from the larger operators available for heavy construction and important building work, although the demand for washed sand and gravel is now greater than the supply. A thorough survey of this district however, would probably uncover an almost inexhaustible supply of good commercial gravel. The region is such that the uncovering of numerous kames, or gravel knolls, would not be unexpected.

A general survey for gravel deposits has never been made. Whatever work has been done is hidden away in the various geological reports and is merely incidental to the main report. Compared with other minerals, practically no prospecting has been done. A few reports have been made by the more advanced operators, but these are only local. If oil or coal is under consideration the, State has mapped out the district and stands ready to lend a hand; but ask about gravel and the only satisfaction is reference to a report published 20 years ago and now out of print. The consequences are that every examination has to be more thorough and more expensive than would otherwise be the case; but an advantage is that the company or corporation knows in advance whether to install a large plant or to confine themselves to a plant which can be charged off before the pit is exhausted. If the sales department is too efficient it is easy enough to increase the capacity or "run a stock pile" by a little overtime; but a large plant never increased the amount of gravel in a pit.

The size of a gravel plant is dependent on the average market available for the product. An over-size plant is a financial failure; an infant is a misfortune. In the first case the fixed charges absorb the profits; in the second case, the capacity of the plant will not supply the

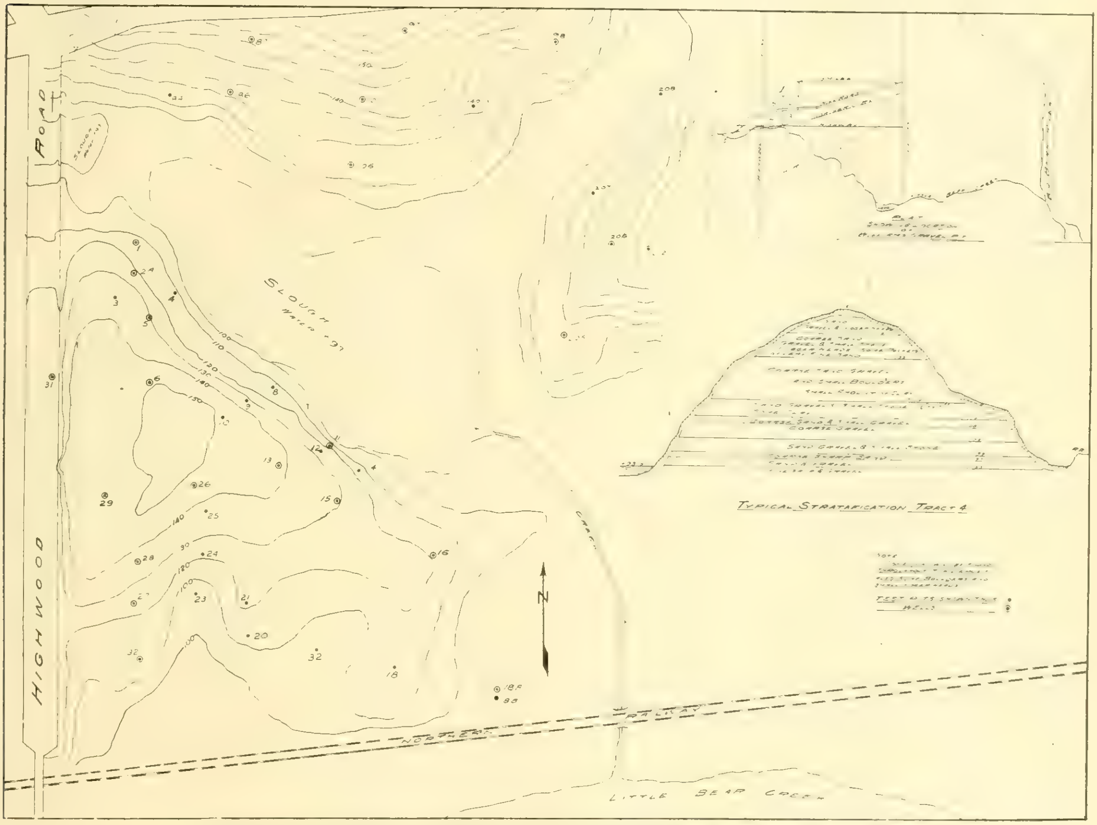


Fig. 1—General Location, Topographic Survey and Test Pits and Test Wells of Gravel Tract.

ordinary demand; the company falls behind on its orders; the screens and machinery are crowded; inferior material is sent out; customers are dissatisfied with both deliveries and grade; complaints come in from all sources and the whole organization is soon "shot to pieces." This is the cause of failure of many apparently prosperous pits. A successful gravel plant can be designed to suit practically any conditions, but there are many features to consider other than the mere detailing of mechanical apparatus. The amount, character and probable life of the deposit, its location and accessibility to the market, the character of the plant, freight rates, storage yards, labor costs, taxes, and a dozen other items, all influence the cost of production. But on the other side of the ledger is only the selling price of material and the by-products. The latter are often sadly neglected, through ignorance rather than design, although their recovery would be an asset rather than a debit. For instance, in one case identifying an ideal moulding sand in a gravel deposit resulted in an asset sufficient to practically offset the cost of stripping, and in another case a worthless deposit of "small nigger-heads" proved to be the most valuable part of the pit.

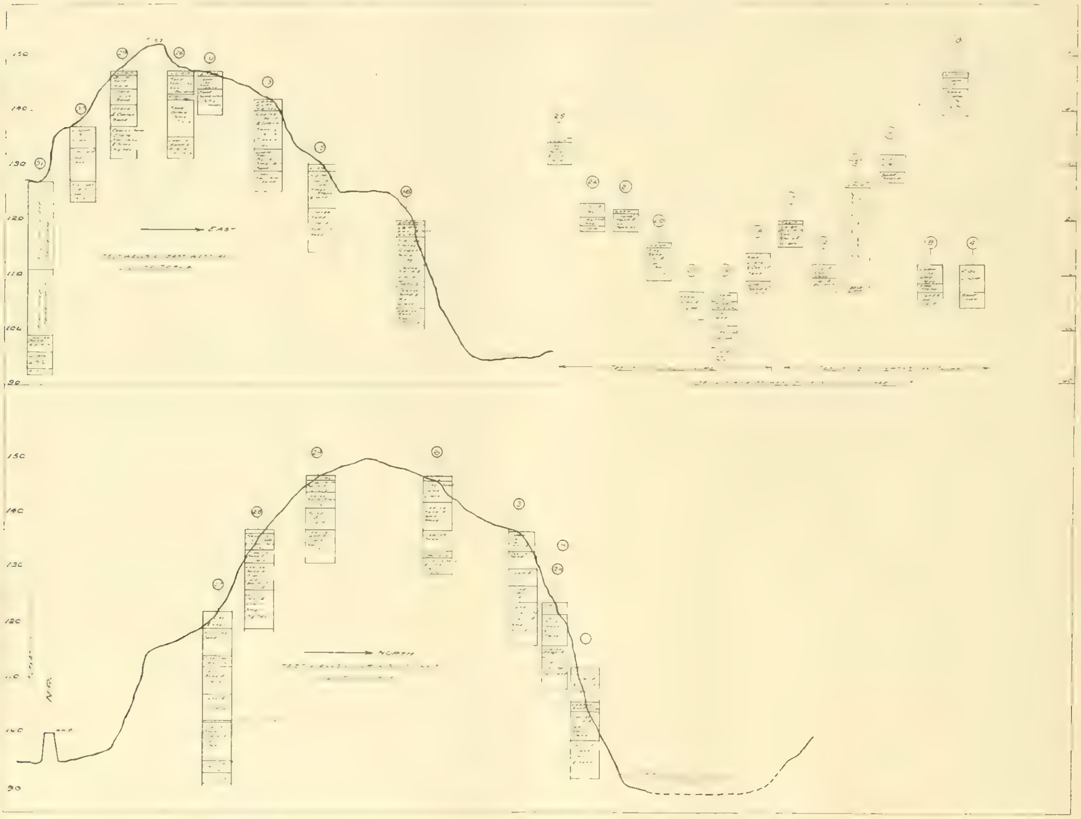


Fig. 2—Test Wells and Test Pits and Character of Material Encountered.

Once in a while the development of a deposit is the secondary rather than primary consideration. Such was the case of a small tract located in a district that slowly but surely was developing into a popular suburb of a growing city of something over 100,000 inhabitants. The surrounding land was held at a fancy price, but this tract, in the existing condition, was practically valueless and the cost of cutting it down to the prevailing grade was more than the improvement was worth. The owner desired an investigation and advice.

A survey was made of the property and an examination started to determine the character of the hill. While this was being carried on information was gathered as to the probable disposition of the material. The sale of cement in this and other nearby cities was comparatively large and the cause traced. To make a long story short, it was discovered that a great number of small cement block manufacturers were doing a thriving business and getting big prices for their product. The examination of the property showed that not only could the owner supply a good material for cement blocks, but he could also derive a fair return on an investment of very little actual money if he cared to enter the field. The only other interest attached to this survey was in that it showed a fine example of lenticular stratification.

The vast amount of good road work throughout the country which is either under way or proposed, has brought the use of gravel prominently to the front and opened up a field never before dreamed of. There is money to be made for the pit owner, but not from poor gravel. He may dispose of inferior material for a short time, but the highway engineers have more experience in road work than the gravel man, and only a short time is going to elapse before the specifications will show the result of their observations. The financiers have awakened and many are insisting on investigation and a report of the deposit before negotiating a loan. The report may merely cover a physical examination of the property or may cover an analysis of the market and other features which would influence the extent of the loan.

The following data are taken from a report made for Robert W. Hunt & Co. and made public through their courtesy. This report was of particular interest on account of the various features covered and the very large tract involved. (The location, for obvious reasons, is not given.)

In order to provide for the progressive development of the property, an examination was first made of the tract as a whole. This was later subdivided into sections sufficiently large to warrant the construction of a complete screening and washing plant for each section.

The general location, topographic survey, and the test pits and test wells are shown in Fig. 1.

Tract 4 was of interest in that it formed a hill or knoll, standing in a fairly level valley. The deposit is evidently one of the hummocks (kames) forming a part of the terminal moraines which cover this part of the state and extends south and easterly over the central states.

During the recession of the glacier, which at one time covered this section of the country, the waters carried away much of the finer material and left the ridges or hummocks of till and partly solidified debris. For a terminal moraine represents not only an accumulation of material transported by the ice, but also deposits which have been modified by the glacial streams. These two conditions have given a resultant structure which ranges from a jumble of boulder clay to well defined strata of assorted sand and gravel. The extremes are not necessarily widely separated, but may—and often are—found in the same hill. Sometimes, too, we find the till or strong clay knolls which resisted erosion pushing completely through the covering of wasted material. On the other hand, we often find the coarser material piled in hills lying in a comparatively flat tract or surrounded by the till or clayey soils. Examples of practically all these conditions are found in the surrounding territory, and in some of the excavations, the various changes are strikingly pronounced.

TABLE I. AUTO TRUCK HAULAGE

2 White 5-ton power dump trucks.
Average haul, 1½ miles. (Total, 6,690 miles.)
Loads, 2,949 (14,745 tons).
Days, 27 (24 hrs.).

FIXED CHARGES	
Depreciation (less tires)	$163.23
Insurance	47.03
Interest (less tires)	61.16
Drivers	277.37
Superintending (prorated)	65.73
Total	$614.52
OPERATION.	
Tires	$397.63
Gasoline	229.92
Oil	62.52
Grease	10.71
Repairs	78.21
Accidents	20.19
Miscellaneous	23.73
	$820.91
Per mile (operation)	.1225
Per mile (fixed charges)	.2084
Per mile (total)	$ .3309
Per ton-mile	.072

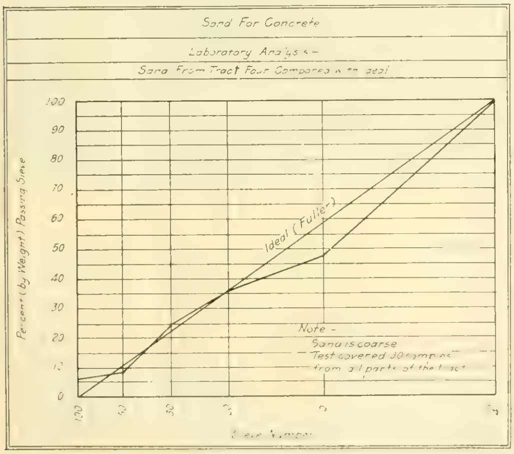


Fig. 3—Comparison of Sand from Tract.

From a study of Tract 4 it is evident that this is what is known as an "out wash" and is a straified deposit of sand and gravel. The boulders deposited on the hillsides and other evidence in the vicinity, are almost conclusive that the deposit was covered subsequent to its formation, and later eroded to its existing contour. It is possible that there is a clay core forming the base of the hummock, but I am of the opinion that the stratification is approximately as shown and very little clay will be found anywhere in the hill.*

Test wells were sunk on the two axes of the hill and test pits sunk at various points to determine the amount of stripping. These are shown in detail (Fig. 2).

Field analyses were made of the material obtained from all the wells and pits, and check analysis was made in the laboratory.

The boulders were estimated at 5 per cent of the whole, and the sand was analyzed in the laboratory and is shown on the accompanying chart (Fig. 3).

The total amount of commercial gravel in this tract was estimated at 59 per cent of the workable contents and was remarkable for the small amount of clay.

This report covered a complete analysis of market conditions, transportation of material by railroad and auto truck, distributing station, yards, design of plant and a financial statement, also an investigation of the various rulings and orders of the Warehouse Commission and the court decisions bearing on this question. One of the data sheets on auto truck haulage is shown herewith (Table I). The figures are taken from the books of another company and represent actual expenditures for the work done.

A plant centrally located may cost a little more to install, but one built on "that flat spot" at one end of the tract will have to bear the burden of pithaul that increases from day to day.

Electric power can be obtained at most places a little cheaper than steam and no coal is being burned during a shut-down, nor at night. Contracts are made on a decreasing basis for an increasing power consumption; and one electrician with a helper does the work of three or more around a steam plant.

A cent saved at the pit is better than the saving on freight rates because you don't need a lawyer to plead the case.

DETERMINATION OF PROPER STOPPING PLACE IN DRIVING A PILE.

The determination of the proper stopping place in driving a pile is largely a matter of judgment and experience. A committee of the American Railway Bridge and Building Association in a report submitted at the recent convention of the association, summarized the methods as follows:

Foreman's judgment without formulae	14 roads
As long as the pile will drive without damage	6 roads
Practical refusal	13 roads
Engineering News formula	4 roads
Special instructions based on investigation and tests	3 roads

Central of Georgia:—3,000 lb. drop hammer with a 20 ft. drop, 1 in. penetration; Bucyrus No. 43, steam hammer, ¼ in. per blow.

Central of New Jersey:—3,000 lb. drop hammer with a 15 ft. drop, 1 in. penetration.

Chicago & Northwestern:—3,000 lb. drop hammer, 30 ft. drop, ½ in. penetration. (Above applies to foundation piles. Engineering News formula is also used.)

Illinois Central:—3,000 lb. drop hammer, 20 ft. drop, ½ in. penetration.

Michigan Central:—3,000 lb. drop hammer, 15 ft. drop, 2½ in. for last 5 blows.

New York Central Lines West:—3,200 lb. drop hammer, 30 ft. drop, ½ in. to 1 in. penetration.

N. Y., N. H. & H.:—2,000 lb. drop hammer, 25 ft. drop, 10 in. for last 10 blows.

Philadelphia & Reading:—2,250 lb. drop hammer, 15 ft. drop, refusal; 3,300 lb. drop hammer, 10 ft. drop, refusal.

St. Louis & San Francisco:—No. 2 Vulcan hammer, 1 in. in 4 to 6 blows.

Toledo, St. Louis & Western:—Penetration of 14 ft. to 16 ft. Conditions uniform.

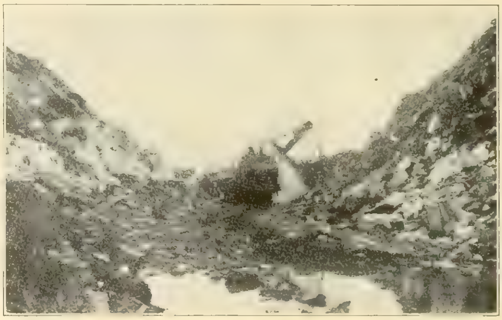
Western Pacific:—Steam hammer on new work, ¼ in. penetration at last blow.

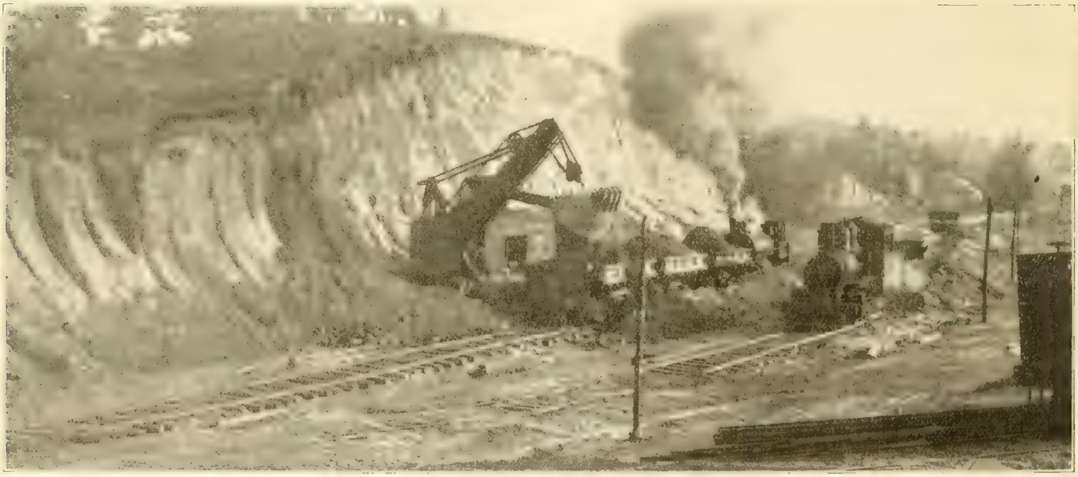
*Later investigation proved this to be correct.

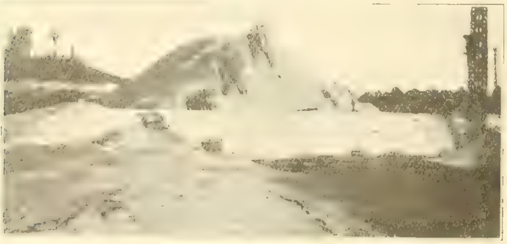
HEAVY EXCAVATION WORK ON SOUTHERN RY.

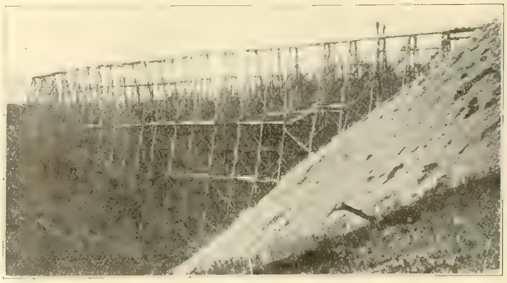
Extensive earth moving operations are now being carried out between Central, S. C., and Cornelia, Ga., in connection with double tracking and line revision work for the Southern Ry. Contracts for this work were let early in 1916. The improvement covers 58 miles of line between the places mentioned and involves nearly 9,000,000 cu. yd. of excavation. Most of this is being done with steam shovels. The work is divided into six sections as shown in Table I. This table also shows the amount of material moved by the several contractors, working from April 1, 1916, to March 1, 1917. The work of the sub-contractors is included in the record under the general contract.

One-Mile Rock Cut in Rinehart & Dennis Contract.


Rock Cut ½ Mile Long in C. W. Lane & Co.'s Contract.


Steam Shovel Operations in Borrowing Material for the Coldazell Fill on the C. W. Lane & Co. Contract.


End View of Fill at Walton Creek, Showing Culvert.


Trestle at Coldazell Creek Fill.

The Lane contract is for 5.9 miles of line revision beginning at Toccoa and extending one mile south of Ayersville. Not a foot of the work parallels the old line. In the original contract there were 800,000 cu. yd. of solid rock, 300,000 yd. of soft rock and 100,000 yd. of earth excavation. A supplemental contract includes what is known as Coldazell fill, where the new line will cross a deep ravine 85 ft. above the original track. There will be more than 1,600,000 cu. yd. of material in this fill, all barrowed. It is stated that this will be the largest fill on the entire Southern Ry. It will be 2,000 ft. long and 180 ft. high. More than one-third of the fill had been completed and the original contract was about 60 per cent done on March 1.

Under the Lane contract the new line will cross over the present track three times in five miles, which indicates the extent of the straightening process: once, 85 ft. above at the big fill; again, 8 ft. above, a little north of Ayersville, and a third time, 6 ft. above, a little south of Ayersville.

The steam shovels were cut in by the Lane company last May to July, this work being accomplished with much difficulty, as the machines and other equipment had to be hauled up the hills with block and tackle. The Lane Co. is using eight shovels in all: one 70-ton Bucyrus, one 80-ton Bucyrus, one 45-ton Atlantic, one Marion rotary and two Osgood 73s. The company is working seven standard gage outfits and one narrow gage, which is making a 200,000 yd. fill against the south end of the abutments for the North Broad river bridge. In addition to these the Marion rotary shovel is loading Western 1½-yd. dump wagons, with which a roadbed is being built in connection with the Coldazell work for the purpose of diverting the main line temporarily.

The Coldazell fill is being built by the two Osgood shovels, working with 12-yd. Western air dump cars and 45-ton locomotives. This fill is being put up in 30-ft. lifts. In this work an average of 100,000 cu. yd. per month has been maintained throughout the winter, notwithstanding some of the worst weather ever experienced in that section. During one day of 10 hours 530 of the 12-yd. cars were loaded and dumped, moving a total of 7,500 cu. yd. of material. One of the shovels has a record of 315 cars in 10 hours, with a haul of 1,000 ft.

Included in this section is a bridge, crossing North Broad River. It will be 1,500 ft. long and its piers will be 210 ft. above the rock foundation. There will be ten of these piers, two of them solid and eight hollow, about 60 ft. square at the base, and two abutments. The foundations go down 20 ft. to solid rock. On these piers and abutments will be laid 11 double track plate girder spans 100 ft. long and 8 spans 26 ft. long.

TABLE I. CONTRACTORS AND WORK DONE FROM APRIL 1, 1916, TO MARCH 1, 1917.

Section.	Miles.	Total yardage.	Yardage completed.	No. of shovels.	Contractor.
Central-Seneca	13	1,550,000	1,090,000	4	E. J. McKinney
Seneca-Westminster	8.6	960,000	918,000	4	Robt. Russell
Westminster-Tugaloo River	9.4	1,870,000	1,220,000	9	Winston & Co.
Tugaloo River-Toccoa	6.3	677,500*	280,000	1	Rinehart & Dennis Co.
		1,130,000	950,000	4	Rinehart & Dennis Co.
Toccoa-Ayersville	5.9	1,634,000†	602,000	2	C. W. Lane & Co.
		1,251,000	746,000	5	C. W. Lane & Co.
Aversville-Cornelia	6.8	1,067,000	919,000	4	H. J. Dunavant

*Includes Dalton Creek fill. †Includes Coldazell Creek fill.

A tower erected on pier No. 8, 270 ft. high, will shoot concrete into four piers; from another tower in pier No. 5 two more will be poured; from a third on pier No. 3 a solid pier and the north abutment will be poured, and so on. In this way the company expects to pour 5,000 cu. yd. of concrete per month. A cableway is used in handling the sectional forms and reinforcing steel.

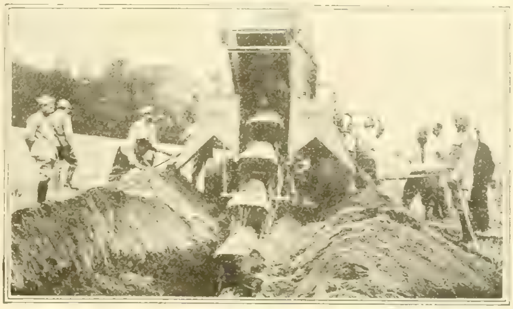
C. W. Lane & Company are working about 700 men altogether, from four camps, with a superintendent at each shovel. L. C. Harris is general superintendent, with his office at Ayersville, and Mr. Lane himself is giving much personal attention to the work. From Dec. 5 until March the work was greatly delayed by unusually bad weather, but the company expects to complete the original contract in July and the supplemental contract by Jan. 1.

Rinehart & Dennis have a contract of similar character, joining the Lane contract on the north. Their contract involves about 1,800,000 cu. yd., a portion of which has been taken over by the Sheahan Construction Corporation. Of this material about 700,000 cu. yd. will go into the Dalton Creek fill. With a Marion 60 shovel and 4-yd. Western cars they are moving from 40,000 to 50,000 cu. yd. per month. The contract includes a solid rock cut of 160,000 yd. which is about completed. This is near the main line and the grade has been lowered 20 ft.

R. O. Parsons is engineer in charge of operations from Sanford to Cornelia for the railroad company. B. L. Crenshaw is in charge of the heavy work through the sections described.

TRENCH DIGGING FOR FRENCH ARMY.

American trenching machinery is being used to a considerable extent in the excavation work for the French and Russian armies. Many of the machines are the ordinary power excavators employed by American contractors in trenching for water mains and sewers. Some of those on the Russian front are gasoline driven excavators designed to cut 6 ft. deep and 3½ ft. wide.



Copyright by Underwood & Underwood, New York City.
Rear View of Motor Truck Trench Digger.

In several instances, however, the French army engineers have made special adaptions of trench digging machines. One of these is shown in the accompanying illustrations. This excavator is built up on a 3-ton Packard chain-driven motor truck and is now in operation somewhere in France along the battlefront. The excavating arrangement is similar to that of American trench excavators. The mechanism is operated by power from the engine of the truck.

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Front View of Trench Excavator Showing Hauling Arrangement.

The front part of the chassis has been lengthened with a steel frame to which is bolted a drum turned by two crank handles. When digging trenches the machine is moved forward by winding up the cable on the drum. One end of the cable is fastened to a tree or deadman. When not being used as a trench digger the truck moves forward under its own power.

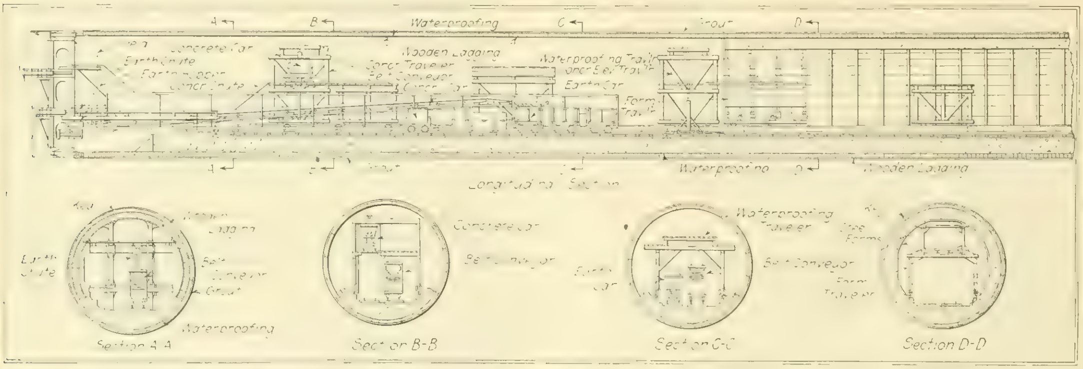
PILING STUMPS AND LOGS IN LAND CLEARING WORK.

The proper piling of stumps and logs is one of the important parts of the land clearing work. Logs and brush should be piled at the bottom of the pile and should be piled as closely together as possible. The stumps should then be piled on top of the logs and brush. The top of the pile should be nearly as wide as the base, and as high as is possible so that when the pile is burning the stumps will settle into the hottest part of the fire and will not leave an outer circle of unburned stumps and logs as is many times the case where piles are simply hauled together. A well built pile will make heat enough to burn the largest of the stumps and require very little "chinking." It will require careful study and some experience to be able to build piles that will burn up clean.

METHODS EMPLOYED IN CONSTRUCTION OF FORT POINT CHANNEL RAPID TRANSIT TUNNEL, BOSTON, MASS.

One of the most difficult pieces of work in connection with the building of the Dorchester Tunnel link of the subway system of Boston, Mass., is the construction of the section under the Fort Point Channel. This section includes two single track tunnels beginning near the intersection of Summer St. and Dorchester Ave., Boston, and extending under Fort Point Channel, private property and streets, a distance of about 3,500 ft. The contract for this work was let on Dec. 16, 1914, to P. McGovern & Co., at a bid of $1,955,375 for about 3,200 lin. ft., this not including an extension of the section. Work on the main shaft in West First St. was started on Jan. 6, 1915. The following description of the construction methods employed by the contractor is taken from the last annual report of the Boston Transit Commission, Edmund S. Davis, Chief Engineer, for the year ending June 30, 1916:

The tunnels are of two types. Between Summer St. and West First St. they are circular in section and are being driven by the shield method under compressed air. The length of this part of the line is about 3,060 ft., of which 2,160 ft. is under Fort Point Channel. Between West First St. and Dorchester Ave. at Broadway, a distance of 370 ft., the tunnels are rectangular in section with arched roofs and are being driven by drift methods, most of the time under compressed air. Work on all four tunnels has been prosecuted from a main shaft located in West First St. The shaft is rectangular, 64 ft. x 70 ft., and its bottom is about 60 ft. below the surface of the street. The earth was mostly blue clay, and its excavation in the shaft and far enough in the tunnels to install the air locks, was successfully done in free air, although very heavy bracing was necessary in the shaft to withstand the earth pressures which developed before the reinforced concrete lining could be placed.



Arrangement of Plant at Heading and Stages in Construction of Tunnel Under Fort Point Channel.

The two shields, which were built for the contractor by the Boston Bridge Works, were teamed to and lowered into the shaft in sections and were riveted up on timber cradles resting on the bottom. The shields are 24 ft. $4\frac{1}{2}$ in. in diameter, $12\frac{1}{2}$ ft. long, and each weighs about 83 tons without the jacks. Each shield is equipped with 24 8-in. hydraulic jacks with a 34-in. stroke. The forward ends of the shield decks are fitted with sliding extension platforms. The platform of each deck is divided into two sections, each section being forced out by two $3\frac{1}{2}$-in. hydraulic jacks. All the jacks work under a maximum hydraulic pressure of 5,000 lb. per square inch. The main jack heads are shaped so that they form a nearly continuous ring of the same diameter and thickness as the outer wooden lining, against which they react when shoving the shield forward. The platform rams keep the extension platforms pressed against the earth at the working face, thus providing necessary support in keeping sandy soil from caving in and preventing excessive flow of the clay.

The outer shell of each tunnel is made of Southern long leaf pine, 9 in. thick and 24 ft. 2 in. external diameter. It is built up of segments accurately sawed to shape, each segment being about 4 ft. 8 in. long, $9\frac{3}{4}$ in. wide, and of the same thickness as the completed lining (9 in.), 16 segments and a short key completing each ring. The segments are assembled in the tail of the shield as fast as it is pushed ahead. The segments of each ring are fastened to those of the preceding one already in place by means of $\frac{1}{2}$-in. steel pins. The pins are inserted in holes drilled in the segments before erection, and then when each segment is in place, are forced into the ring behind by means of the shield jacks.

Before placing the concrete lining a waterproofing membrane is applied to the interior surface of the wooden shell. This membrane consists of three layers of an asphalt saturated cotton fabric mopped with hot asphalt. In applying the waterproofing the first layer of cloth is mopped with hot asphalt on one side and then nailed to the wood, the mopped side being next to the wood. The second and third layers are then stuck on with successive moppings of hot asphalt.

The concrete lining has a standard minimum thickness of 2 ft. and in general is not reinforced. Some reinforcement was used on the westerly side of the arch of the easterly tube in order to take care of the temporary stresses resulting from the passage of the shield of the westerly tunnel, which was usually a few hundred feet behind the heading of the easterly one. The horizontal displacement of the easterly tunnel, due to the driving of the westerly one alongside of it, with about 5 ft. clearance between them, was about $\frac{3}{8}$ in.

A belt conveyor about 110 ft. long is attached to the rear of each shield and is pulled along as the shield advances. It runs on one of the two narrow gage working tracks which are laid on the invert of the tunnel as fast as the later is put in place. The belt conveyors serve to convey the excavated earth past the points where the operations of placing the wooden lining, waterproofing, invert concrete and grouting outside the wooden lining are going on and so avoid interference with them. The earth is discharged from the conveyors into muck cars, which are pushed, one at a time, under the discharge chutes about 100 ft. in the rear of the shields. All the hauling of construction materials and of excavated earth through the tunnels is done by small electric locomotives operated by storage batteries.

Concrete is brought into the tunnels in steel cars containing about 1 cu. yd. and is hoisted by means of elevators to overhead platforms before being shoveled into the forms. There are two of these concrete elevators at the heading of each tunnel. The forward ones for invert concrete are just behind the shields and hoist concrete cars from the construction tracks alongside the belt conveyors. The rear ones which are used for arch concrete are just behind the belt conveyors and hoist the concrete cars from the same track that the conveyors run on.

The elevators and overhead platforms span the construction tracks and the belt conveyor, and travel on two rails which are supported on the lower concrete duct line benches along the sides of the tunnel.

Blaw steel forms are used for placing the concrete in the walls and arches. These forms are made up in 5-ft. panels. Three of the panels (15 ft. of forms) are handled as a unit by means of a steel traveler which runs on the same rails as the concrete elevators and overhead platforms. The forms are made collapsible so that a panel at the rear can be lowered on to the traveler and moved ahead under the forms still in place and set up in its new position just ahead of the completed arch.

The sequence of the various steps in the construction of the tunnel is as follows:

(1) Excavating ahead of the shield about 20 in.

(2) Shoving the shield ahead about 20 in.

(3) Assembling two rings of the wooden lining in the tail of the shield.

(4) Waterproofing the invert. (Ordinarily done in 15-ft. lengths.)

(5) Concreting the invert. (Ordinarily done in 15-ft. lengths.)

(6) Grouting outside the wooden lining. (Carried on at the same time as 4 and 5.)

(7) Waterproofing the walls and arch.

(8) Concreting the walls and arch. (Ordinarily done in 15-ft. lengths.)

(9) Grouting any spaces left between the waterproofing and the concrete at the top of the arch.

Three air locks are set in the bulkhead of each of the channel tunnels. The two lower locks, used for taking materials in and out, are each 50 ft. long and 7½ ft. in diameter. The upper lock, used by the workmen, is 30 ft. long and 6 ft. in diameter.

The cars carrying the earth out of the tunnels are hoisted up the shaft on elevators to an overhead trestle above the street. Here they are dumped into larger cars, which are hauled over a trestle several hundred feet by means of a dinkey engine to the edge of the channel, where the earth is dumped into scows.

The easterly and westerly shields were driven 180 and 105 ft. respectively from the shaft in free air before the excessive flow of the blue clay made it necessary to install the air locks and put the headings under compressed air. The maximum range of air pressures used varied from 12 to 28 lb. gage per square inch. For the greater portion of the distance the air pressure was kept between 18 and 22 lb. gage per square inch. For a short time when the easterly tube was about 300 to 400 ft. south of the Summer St. bridge it was necessary to raise the pressure to between 26 and 28 lb. in order to drive through some water-bearing sand pockets. The water encountered at this point was fresh and under a higher head than that of the channel above. On this account it was impossible to hold the air in the tunnel at a pressure sufficiently high to dry out the sand, as the earth overhead was too thin to resist the pressure, and excessive blowouts resulted. The difficulties at this point were finally overcome by depositing a clay blanket on the bottom of the channel over the heading, to help in holding the compressed air, and by completely timbering the face of the heading at the front of the shield and working the boards ahead one at a time.

The shield for the easterly tube was started May 8, 1915, and was stopped from June 12 to June 29, 1915, while the air locks were being installed; also from July 28 to Aug. 23, 1915, while the belt conveyor was being installed. The shield for the westerly tunnel was started June 15, 1915, and was stopped from June 26 to July 30, 1915, while the air locks were being installed, and from Sept. 27 to Nov. 7, 1915, while the position of the air locks was being changed and the belt conveyor was being installed. On June 3, 1916, the shield of the easterly tunnel was driven through to Section D, the end of the tunnel already completed in Summer St., and after removing all of the shield except its shell, the concrete arch was finished on June 27, 1916.

Working three 8-hour shifts per 24 hours the progress which has been attained for various times is as follows:

Maximum 24 hour run for one shield—19 ft.
Maximum 7 day run for one shield—105 ft., or 15 ft. per day.
Maximum 30 day run for one shield—400 ft., or 13½ ft. per day.
Maximum 3 months run for one shield—375 ft. per month, or 12½ ft. per day.

The sustained progress over a period of 8 or 9 months, including all shut downs and delays for holidays, repairs, etc., was at the rate of 9.3 ft. per day for the easterly tunnel and 10.8 ft. per day for the westerly tunnel. The above figures are for completed tunnel, including the concrete lining.

It is probable that a sustained progress of about 15 ft. per day could be maintained with the tunnels entirely in blue clay.

Experience on this work indicates that the following rule for the time taken by the men to decompress from the pressure in the tunnel to normal atmospheric pressure gives reasonably satisfactory results:

For pressure up to 12 lb. gage—no time limit necessary.

For pressures from 12 to 28 lb. gage—one minute for each pound that the gage pressure in the tunnel exceeds 12 lb.

An occasional man, even when passed by competent medical examination, seems to have an individual susceptibility to some form of compressed air disease, and there is no practicable rule for decompression which probably entirely eliminate trouble from this cause.

Some construction data on the Fort Point Channel work follow:

Amount of work done during the year ending June 30, 1916: Excavation, by shield method, about 100,298 cu. yd.; in drift tunnels, about 10,294 cu. yd.; concrete placed, in shield tunnels, about 30,585 cu. yd.; in drift tunnels, about 3,857 cu. yd.; long leaf pine lumer used for outside tunnel lining, about 3,829 M ft. B. M.

Total amount of work done from beginning of work to and including June 30, 1916: Excavation, by shield method, about 104,882 cu. yd.; in shaft and drift tunnels, about 21,794 cu. yd.; concrete placed, in shield tunnels, about 31,469 cu. yd.; in shaft and drift tunnels, about 5,804 cu. yd.; long leaf pine lumber used for outside tunnel lining, about 3,895 M. ft. B. M.

Number of men ordinarily employed by the contractor during the year ending June 30, 1916: First (day) shift, about 340; second (evening) shift, about 180; third (night) shift, about 180.

Character of earth found in excavation: In general, medium stiff blue clay at upper portion of tunnel section. Hard mixture of sand, clay and boulders at lower portion of tunnel section. Ledge of rock extending up into the tunnel section to 10 ft. from the bottom for a length of about 220 ft. This ledge varied from quite soft to medium hard material, and most of it required blasting for removal. Some sand pockets a short distance south of the Summer St. bridge.

Disposition of surplus earth: Delivered to scows and used by sub-contractor for filling East Boston flats.

HOW TO GET FULL AND PROMPT CREDIT ON EMPTY CEMENT SACKS.

The following rules for handling empty cement sacks have been issued recently by the Universal Portland Cement Co., Chicago:

Value of Cloth Sacks.—A carload of sacks is worth more than a carload of cement. Good and repairable cloth sacks are worth 10 ct. each. All other sacks are worthless. Storing large numbers of empty sacks ties up money that earns no dividends. Prompt shipping of sacks brings prompt credit to dealers and sacks to the manufacturer.

Parties Involved.—Railroads handle hundreds of carloads of sacks. They cannot be expected to have the same interest in one bundle as a shipper, especially when their rules are not observed. Manufacturer handles millions of sacks a year. He is anxious to give shipper credit with minimum of trouble. Shipper can reduce tedious delays to a minimum by observing rules of railroad and following suggestions of manufacturer.

Railroad Rules Specify in Part That—Bundles must be tied with three separate wires or ropes. (If rope is used it must be not less than 3/16 in. in diameter.) Bundles must be tagged with linen tags, securely attached by wire. Freight must be prepaid to destination.

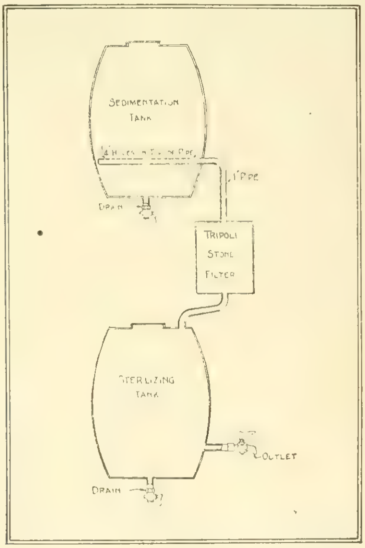
Tags.—Must contain name and address of consignee. Must contain name and address of shipper. Should contain name and address of party to whom credit is to be issued. Should show number of bundles and total number of sacks in shipment. Note:—Filling out blanks completely makes issuing of credit easy and simplifies sorting of thousands of individual shipments received by manufacturer.

Routing.—Shippers should insist that full routing to destination be shown in space provided on bill of lading in order to minimize delay in transit.

Credit.—Bundles must be identified before credit can be issued. Identification card or letterheads inside of bundle insures identification even if tag is lost in rough handling, provided only that bundle reaches destination intact. Failure to send bill of lading delays credit as shipment often is received by manufacturer before railroad furnishes proper billing. Tags properly filled out enable manufacturer to tell immediately: (a) Total number of sacks in shipment; (b) name of shipper; (c) name of party to be credited.

WATER PURIFYING DEVICE.

A device for purifying drinking water, that might be applicable to large construction camps, is employed by the Illinois Central R. R. The following description of the arrangement is taken from an article by Dr. Albert E. Campbell, Health Officer Illinois Central R. R., in the Chicago Medical Reporter: At certain places where the drinking water used by employes is taken from a pond, brook or river two large barrels as shown in the sketch are used—one as a sedimentation tank—the other to sterilize the water. In order that all foreign matter may be removed a Tripoli stone filter is placed between the barrels, as lime does not destroy bacteria in the presence of much foreign matter. Lime tablets are used in the lower barrel.



Standard Method of I. C. R. R. of Purifying Water.

The State legislature of Iowa has passed a law requiring the patrol system of maintenance on all county highways.

METHODS AND COST OF CHANGING 17 MILES OF RAILROAD TRACK FROM NARROW GAGE TO STANDARD GAGE.

Contributed by Henry R. Somes.

The railroad on which this work was done was built during the 1880's as a narrow gage road. It runs from Wilmington, Vt., to Hoosac Tunnel Station at the east end of the Hoosac Tunnel on the Fitchburg Division of the Boston & Maine R. R. The length is about 25 miles, and as it runs along a narrow valley bordering the Deerfield River it is a line of sharp curvature and short, steep grades.

The cost of transferring all freight at the Hoosac Tunnel had proved so heavy that preparations, extending over several years, were made to widen the gage.

The old rails being much worn, enough second-hand rails were purchased to relay the line. These were 56 lb. to the yard and were purchased of the Ulster & Delaware R. R. About 8½ miles of the line from the Wilmington end were relaid to standard gage outside the narrow gage iron. On the rest of the line the old iron was replaced by these rails, they being laid narrow gage as the ties and roadbed were not in condition to carry standard gage equipment. In many cases the fills were so narrow on top that there was not sufficient shoulder to safely operate. The road was equipped with short narrow gage ties; many of them were so old that it was not safe to spread the track until these sections of the line were re-tied.

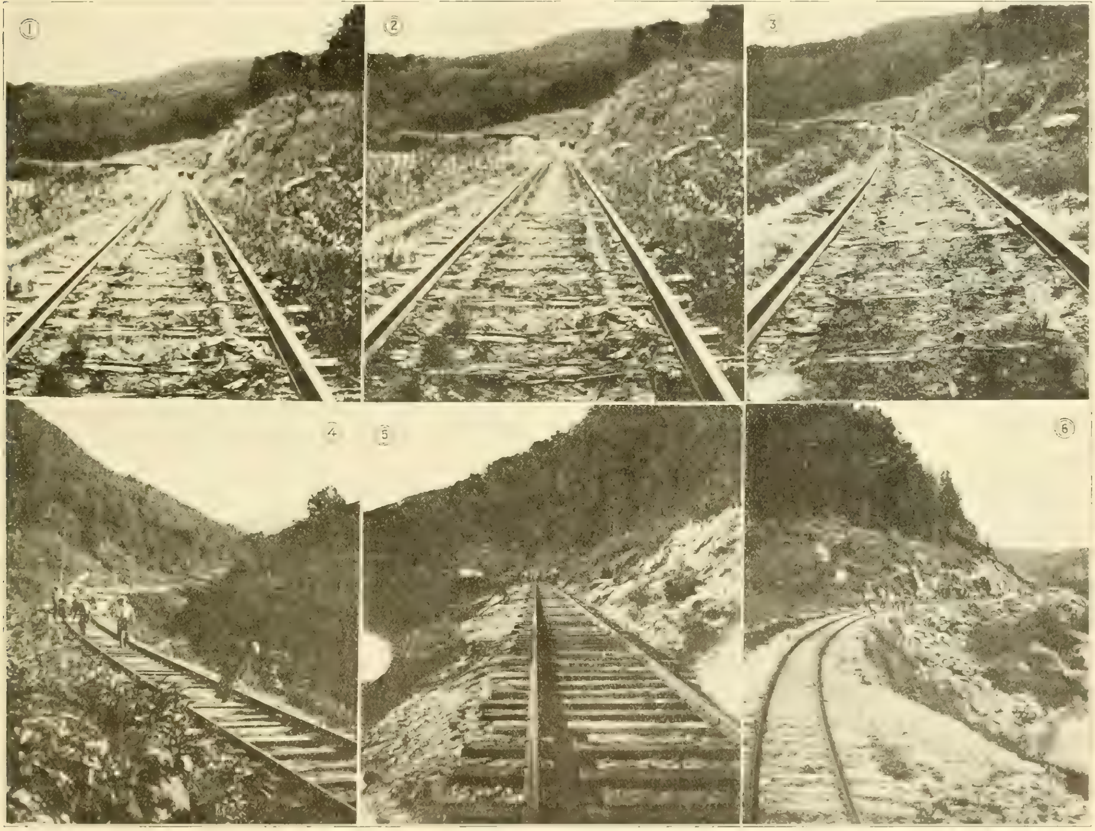
It was reported that the railroad force started to change the gage in 1912 and did change about a mile, but on attempting to operate a standard gage engine over this piece of track the ends of the ties sheared off and the engine narrowly escaped going over the embankment; so the rails were put back until that section could be re-tied.

The condition of some of the ties and roadbed at the time the entire line was changed may be seen by inspecting Figs. 1, 2 and 3. Four passenger trains and two freights per day were being operated over the line at the time the work was done.

In 1913, after some negotiations, a contract was let for changing the 17 miles northerly from Hoosac Tunnel Station. This portion of the line followed the windings of the Deerfield River and lay in a narrow valley with high hills on each side, as may be seen in Figs. 4, 5 and 6. There were many long, sharp curves, the map of the road showing about 120 curves of 6° or over in the 17 miles. The track was laid with 4-bolt angle bar splices except about 1½ miles where Fisher joints had been used. The first 5 miles had been re-tied where needed and was in the condition shown in Figs. 4 and 5; average condition of the balance of the track is shown by the other illustrations.

The work was carried out during July, 1913; the contractor lost money on the job, which loss was due to several factors, some of which were: Labor was scarce and hard to get, and very inefficient. Experienced men could not be obtained and the job was so short that green men could not be properly broken in. The method employed (which was specified by the railroad company) did not allow time to familiarize the men with their work, or allow the work to be started with a small force and gradually increased. There was no labor to be had in the territory tributary to the line and the contractor was obliged to pick up green men in the cities and use them. The weather was excessively hot, and the road lying in a narrow winding valley, the wind could not cool the air; this reduced the output of the men to a marked degree. When men were hired it was with the understanding that experienced spikers were to be paid 25 ct. per hour, and other laborers 20 ct. per hour, but during the first afternoon about two-thirds of the men (inexperienced) struck for 25 ct. per hour. The contractor was up the line when this occurred and an engine was sent after him. The president and general manager of the railroad was at the scene of the work, and being afraid there would be delay, went among the men, conversing with them and giving them to understand that the other parts of the work were as difficult as spiking, and they should be paid as much; that it was a rush job and they must not leave, and that he would see that their demands were granted. When the contractor arrived the strikers informed him of their demands and that the railroad manager practically backed them up; his foremen corroborated their story. There was nothing else to do apparently but grant their demands, which was done, thereby increasing the cost. When the contractor intimated that he should have more pay, the railroad manager refused to consider it. As it turned out, the contractor should have thrown up the job then, either abandoned it or made a new contract.

Much time was necessarily lost each day in transferring passengers, mail, baggage and express, amounting to two hours per day for the whole gang, as noted farther on.



Figs. 1-6—Views Showing Condition of Ties and Roadbed at Time Gage Was Changed.

Owing to financial difficulties on other work, there was considerable trouble before the labor was all paid up and the job settled. After working a few days, so many of the green men dropped out that the contractor employed 25 men from the railroad company that were more or less used to track work, and so kept his forces at about the same number.

The terms of the contract were as follows:

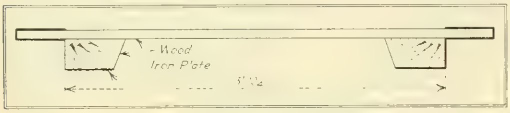
> The party of the second part will on the thirteenth day of July 1913, begin said work with at least 80 men and will prosecute the work thence diligently spreading at least two miles a day so that the whole main line of railroad including frogs and switches from the northerly switch at Hoosac Tunnel, Mass., to where the 4 ft. 8½ in. gage rails are at present laid at Jacksonville siding on said line will be so widened or so standard gaged by the evening of the twentieth day of July, 1913; in doing said work the party of the second part is to adz off all ties where necessary so that the rails will be evenly laid in good line, draw all spikes holding rails at said 3-ft. gage and spread each rail equal distances from the present center line of track, and solidly and securely spike them so that they will be standard, 4 ft. 8½ in. gage except on curves, where it is necessary to widen the gage slightly so as to accommodate the operation of standard gage equipment; cut, rebore and bolt securely where necessary, rails to make them conform to the requisites of a well spiked and bolted railroad track as perfectly as the present 3-ft. gage track is; in cutting rails a neat close fitting joint is to be made and angle or other plate securely and properly bolted in a good workmanlike manner, and such cutting of joints is to be done at such points as will afford the strongest track when completed; switches and frogs on the main line are to be moved and placed in position to accommodate standard gage operation and placed at such places and in such manner as the representatives of the party of the first part may direct; all spikes in use holding the rails to be spread are to be drawn (and if bent in drawing shall be straightened) and securely and properly driven for holding the rails in their new position. And all bolts and plates in use in holding joints and rails in their narrow gage position are to be used in holding and making the joints of the rails in their new position; in spiking the rails in their new standard gage position, four spikes to a tie shall be driven and care shall be taken to drive the spike in such part of the tie as may afford the best holding of the rails and the spikes shall be fully driven so that the head shall rest on the rail and the rail rest on the tie solidly and securely, all said spikes to be driven and the work done in a good workmanlike manner and subject to the approval and inspection of the party of the first part. Said work is to commence at said northerly switch at Hoosac Tunnel and work northerly, and at schedule time of passenger trains on the railroad of the party of the first part the men shall be working in as compact formation as possible so that there shall be as short a distance of transfer as possible for the transfer of passengers, baggage, and express past where the men of the party of the second part shall be working and the men of the party of the second part will at such times render all necessary assistance in transferring passengers and property from standard to narrow gage train and from narrow to standard gage trains so that the same may be as speedily done as possible. In the conduct of said work it may be necessary to use additional spikes or bolts which additional spikes or bolts the party of the first part agrees to supply along its line at convenient places to be reached by the parties of the second part. And the party of the first part is to transport from

Hoosac Tunnel the employes of the second part for said work and to transport them morning and evening from and to their camping place on the line of said railroad company.

There was also a clause empowering the railroad company to take over and carry on the work if the contractor failed to carry it on "during a period of 24 consecutive hours."

The method employed was specified and insisted upon by the general manager and superintendent of the railroad. The contractor did not approve of it, as he wished to use a method that would allow part of the work to be done on a certain section while the narrow gage trains were being operated over it. He wished to drive part of the spikes at such a position on the ties that the rails could be thrown out against them. He would also have pulled part of the spikes while traffic was being carried on, as schedules could have been easily changed to operate at slow speed over these portions until the rails had been thrown to the standard gage. The railroad authorities would not consider any method but their own, and the contractor finally agreed to use it.

The method employed was to divide the men into two gangs and work each gang on a separate line of rails, pull the spikes on one line of rails, throw them out 10¼ in., and respike, while another gang followed at a reasonable working distance, pulling spikes on the opposite line of rails, throw it to standard gage and respike. Of course on the long, sharp curves the outside line of rails would soon stretch so that it would be necessary to break open a joint and start spreading again at the break; the inside of the curve would crowd so that it would have to be broken open and another start made there. As there were many of these breaks, three or four to each long curve, a separate gang was organized to connect up the track at these points.



Special Gage Bar.

The short ends of the rails on the inside of the curves were sawed off with the hack saws, and additional holes drilled in the ends of the rails for the angle bars. On the outside of the curves where the rails were too short, a rail was unbolted, cut in two with cold chisels and a longer piece cut from an extra rail and inserted in the line, making a better job than by putting in a short piece. The spiking gangs followed immediately behind the gangs that were spreading rails, leaving gaps where joints were broken open; the gang repairing breaks spiked the track at these points.

Pulling spikes—	Per Mile.	Total.
2,001 hours @ $0.25		$500.25
Per mile 117.7 hours	$27.42	
Foremen, 2 *(1 @ $10 per day) (1 @ $3 per day)		71.50
Foremen, per mile	4.21	
Average gang, 14.73 men	$33.63	$571.75

The claw bars had heels and worked satisfactorily. The spikes pulled much easier from the new ties than from the old. In the latter they were rusted in and in many cases where the ties were checked and splintered, the splinters raised up even with or above the spike heads and made it difficult to get the claw bars under the spike heads.

Throwing rails—	Per mile.	Total.
762 hours @ $0.25		$190.50
Per mile, 44.82 hours	$11.20	
Foremen, 2 (1 @ $10 per day) (1 @ $3 per day)		17.00
Foremen, per mile	1.00	
Average gang, 6 men	$12.20	$207.50

Ordinary lining bars were used for throwing the rails. Owing to the splintered condition of the old ties, causing the rails to catch, it took longer on that part of the track than on the section that had been re-tied. Broken stubs of spikes also caused delay. A special gage bar was made for getting the gage of the first line of rails thrown. This was made of wood shod with iron as shown in the sketch.

Spiking—	Per mile.	Total.
6,438 hours @ $0.25		$1,609.50
Per mile, 378.7 hours	$ 94.68	
Foremen, 2 (1 @ $10 per day) (1 @ $3 per day)		146.50
Foremen, per mile	8.62	
Average gang, 48 men	$103.30	$1,756.00

Much time was lost during the first few days until the green men had acquired some skill. This occurred on the lower section that had been retied and no other difficulties were experienced except the strike before mentioned, and the great heat.

When the old section of the track was reached much trouble was experienced with spiking. The hard shell on the ties made it difficult to enter the spike, and if the tie was at all splintered spikes would rebound so that at times it was necessary to have one man hold a spike while another started it. On this section the spikes were old, and many bent in pulling. These had to be straightened before using, as the railroad was very economical with spikes. Ties averaged 21 per rail as against 17 on the B. & M. R. R. Therefore a mile of this track meant pulling and spiking equal to 1.25 miles on the latter road.

Adzing ties—	Per mile.	Total.
249 hours @ $0.25		$62 25
Per mile adzed (9 miles)	$6 92	
Foremen included in spikers.		
Average gang, 3 men.		

It was necessary to adz only an occasional tie, and this was done by a small gang that worked ahead of the spike pullers.

Cutting Curves, Drilling, Bolting, and Setting Over Frogs and Switches.

Cutting curves—	Per mile.	Total.
978 hours @ $0.25		$244.50
Per mile, 57.53 hours @ $0.25	$14.38	
Foreman @ $4 per day		60.00
Foreman, per mile	3.53	
Average gang, 7 men	$17.91	$304.50

The short ends of the rails were cut with hack saws, the long rails with cold chisels. Gang would cut and connect up from 6 to 13 breaks per single line of rails with the saw, and the same amount with the chisel, each day. The number of breaks taken care of per day depended on the amount of curvature encountered. Days when few cuts were made the gang spent a large part of their time moving from curve to curve or helping the rear spiking gang. This gang had a push car to carry their tools and usually carried one extra rail. This gang made the cuts, drilled one hole on each side of the cut, put on angle bars and spiked the rails at the breaks. The balance of the work was done by another gang that finished drilling the required number of holes, put in the bolts, and completed any other necessary work. Each break on a curve necessitated a cut with the chisel and one with the saw. The hack saws were 14-in. blades in a high frame, and 2 men would make a cut in 20 to 30 minutes.

Each break cost, average of 10 per day—	
Labor, 7 hours @ $0.25	$1 75
Foreman, 1 hour @ $0.40	.40
	$2.15

Drilling rails at breaks and bolting—		
883 hours @ $0.25		$220.75
Per mile, 52 hours @ $0.25	$13.00	

Gang 6 men in 2 gangs who worked without foremen. Each gang averaged drilling and bolting 25 holes per day.

Paulus track drills were used. The drills were sharpened in the railroad shop and sent out to the men by the passenger trains.

Frogs and switches were merely set over and spiked. This work was carried out by the gang cutting curves. Balance of switch work and yard work was done by the railroad forces. There were 30 switches on the line and the average cost of setting them over was:

Labor, 4 hours @ $0.25	$1 00
Foreman, ½ hour @ $0 40	20
	$1.20

The railroad had a small gang following about 2 days behind that put rail braces on some of the curves.

Miscellaneous expenses—	Per mile.	Total
Water boy		$ 48 85
Labor, 8 hours @ $0.15; 8 hours @ $0.20, per mile	$2.80	

Superintendence—		
16 days @ $8 00		$ 128 00
Per mile	$7 53	

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*Includes extra payments to 4 men that acted as working foremen. These payments are added to this foreman's pay for simplicity in figuring.

Development expenses—			
Fees of men, employment bureau			$18.00
Fares of men			92.52
Freight on tools and supplies			21.92
Traveling, superintendent			20.00
Rent of camp			25.00
Liability insurance			120.00
Tool charges			50.00
Superintendent's time; looking over job; finding men, making preparatory arrangements, hiring camp site, etc., 8 days @ $8.00			64.00
Per mile		$24.21	$ 411.44
Camp outfit for taking care of 65 men—			
Blankets	$ 62.15		
Mattresses	131.50		
Cooking and eating outfit	85.61		
	$279.26		
Less salvage	40.00		239.26
Per mile		14.08	
Development and camp expense		$38.28	$ 650.70
Total costs			$3,946.30
Total costs, per mile		$235.58	
Total costs less development expense		$197.29	$3,295.60

The railroad furnished a work train made up of an old passenger coach and two flat cars. This train carried the gangs to and from the camp and carried a few rails, ties, several kegs of spikes, and tool boxes. This train remained at the head of the work all day, just ahead of the spike pullers.

Comments.

Some of the men were obtained from employment agencies 50 miles away. Others came from cities about 20 miles distant. This accounts for the item of fares.

Two old vacant houses and an old barn were obtained for camp purposes, situated about the middle of the job, and rent was paid as above noted.

Arrangements were made to have about three-fourths of the men Italians and the balance Americans, and camp outfit and layout were made accordingly, but when the gang showed up about four-fifths of them were Americans. This caused much trouble and confusion during the first two days, as they had to be fed, provided for and taken care of, whereas the Italians would have looked out for themselves, shelter only needing to be provided. So cheap mattresses and blankets were hurriedly purchased and sent in by auto truck, and a cooking outfit gathered up near by and four men who had cooked in lumber camps were installed to take care of them.

The men were charged the actual cost of the food, fuel, and labor necessary to take care of them. They wanted to live well, and it cost about $5 per week to board them. The labor cost of this was about $0.15 per day per man.

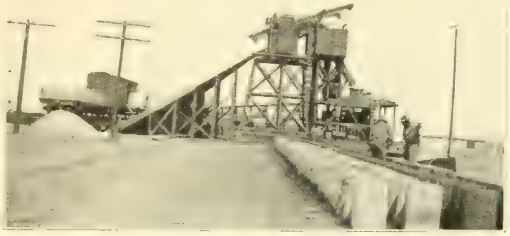
The working time for the 17 miles was 14.3 days, making a speed of 1.19 miles per day, and as the ties averaged 21 to the rail against 17 on some other roads, it would have meant a speed of about 1.5 miles on the latter. There was considerable delay due to transferring passengers, express and mail from the narrow gage to standard gage trains and vice versa. About one-half hour before the train was due at the working point it was necessary to stop pulling spikes and set these men at other work. When the trains arrived nearly all the gangs would help transfer mail, baggage and express. This operation could not be hurried, as neither train could move until the passengers had left the one and boarded the other. Passengers did not take kindly to the operation and showed no desire for speed. Of course after the gang stopped pulling spikes, the other gangs would gain on them and the entire force would be bunched together and working inefficiently until the spike pullers had gained a proper lead again. This delay amounted to about one-half hour for the entire gang for each train, and as there were four of these transfers per day, the delay from this cause amounted to two hours per day, so the gang was only working effectively about 80 per cent of the time.

The only accident during the operation was the derailing of the standard gage locomotive while proceeding at very slow speed around one of the curves. This was caused by a flange of the drivers climbing the rail at a joint where a new piece of rail had been put in. The heads of the old rails were badly worn and as the piece inserted was in good condition it did not make a smooth joint at the gage line. The locomotive was replaced in about one-half hour by replacing frogs. The new rail was removed from the curve and an old piece put in that matched up with the rest of the track.

The aim of this article has been to so describe the work that all factors affecting the management and costs thereof would be shown and deductions made therefrom. It is realized that experienced track gangs could have shown lower costs, but conditions often change between the time when a proposal is made and the time of starting work, and after a contract is signed "it is a condition that confronts us, and not a theory."

DRAGLINE ELEVATES GRAVEL TO MIXER BUNKERS.

Gravel handling in connection with the supply of aggregate for use in casting concrete pipe for a large irrigation development in California is simplified by the employment of an arrangement shown in the accompany illustration. The gravel is brought in railroad cars and dumped into a pit at the foot of an incline. A dragline operated by one man elevates the gravel into the bunkers over the mixing plant. This arrangement is being used by Bent Bros., Contractors, Los Angeles, Cal., for their concrete pipe contract at Henrietta, Cal.



Gravel Handling Plant of Bent Bros. at Henrietta Cal.

CAUTIONS FOR SHOVEL RUNNERS IN MOVING A SHOVEL.

The following suggestions regarding the moving of a steam shovel are reprinted from the May Excavating Engineer:

When moving a shovel back it is important to keep the dipper as close as possible to the bottom of the cut without interfering with the track. Don't have the dipper hanging with steam on the crowding engines. While the machine is standing waiting for a track to be laid the steam naturally gets down in the boiler and the fire will be bad. When you start to move, therefore, a great portion of the power will be taken from the crowding engines and the dipper will drop, endangering those who are in front of the shovel and tearing up the track.

Another important thing to remember is not to neglect to chain the circle, in order to keep the boom from swinging. For when the shovel is being moved the back end may get off the track, the shovel may settle on one side or a rail may break, which would be apt to cause the shovel to start to tip over. Nine times out of ten there would be water in the swinging engines as the shovel has probably been standing by while the track was being laid. Hence there would be no power to swing the boom back and balance the machine. As a matter of fact, even though there were live steam, it would be very difficult to keep from losing control when the boom has swung far over to the side.

To prevent absolutely such an accident as this, it only takes a few minutes to fasten one end of the chain over the A-frame and the other end to the turn buckle clevis on the circle. By so doing you will not only save yourself from the possibility of accident but you will probably save the firm for whom you are working much money and valuable time.

ACCIDENT PREVENTION IN QUARRYING.

The prevention measures that should be adopted in order to avoid the chief hazards in quarrying operations are outlined in the April Travelers Standard, a monthly publication of the Engineering and Inspection Division of The Travelers Insurance Co. and the Travelers Indemnity Co., Hartford, Conn. The notes that follow have been taken from the above mentioned paper.

When a deposit of desirable stone or marble has been located, the first step toward developing it properly consists in the removal of the overburden or soil covering, which should be stripped off to a point well beyond the quarry limits. The face of the undisturbed overburden should present a gradual slope rather than a sharp or nearly vertical rise from the bared rock to the surface of the ground, because the covering of soil is almost invariably of a loose nature when compared with the quarry deposit. Rains, or thaws of frozen ground, may cause slides of soil, or may loosen rocks and boulders; and unless the face is in the form of a gradual incline, and the stripping is carried well back from the edge of the quarry, the sliding material is likely to pass over the rim of the quarry opening and fall upon the workmen below. The stripped zone or surface, lying between the undisturbed overburden and the edge of the quarry opening, should be kept clear of any soil that may be set down by occasional slides. If this is neglected the overburden will gradually work toward the rim of the quarry opening, and thus present an easy path for rocks or other material to fall into the quarry. As an added protection, a substantial fence should surround the quarry.

Machinery actuated by compressed air, steam, or electricity plays an important part in the successful operation of a quarry. Compressed-air drills are used wherever possible, the air compressors being operated by electric motors or by a steam engine, and the air being led to the drills by means of hose. The same sources of energy are used for the operation of channeling machines, hoisting apparatus, and derricks, and for haulage purposes.

Frequent inspection and proper care of the apparatus furnishing power is an essential feature of accident-prevention work. Steam boilers, whether in a power plant, or attached to a derrick or hoist, or constituting parts of self-contained machines in the quarry, should have thorough inspection and hydrostatic pressure tests twice a year, even though state laws or the regulations of insurance companies do not require it. Compressed-air tanks or reservoirs, although not subjected to such a great range of temperature as steam boilers, are none the less called upon to withstand high pressure, and for that reason they should receive the same care and tests as boilers.

One of the most frequent causes of accidents in connection with air compressors is the vaporization and ignition of lubricating oil of low flash point, especially when such oil is used in excessive quantities. Soapy water into which a small quantity of flaked graphite has been introduced forms a lubricant free from explosive possibilities. The graphite quickly adheres to the metallic surfaces and with the soapy water forms a smooth layer between the cylinder and piston. The graphite will not volatilize or become converted into grit by the heat generated during the operation of the compressor. If the compressor should be shut down for a time there might be a tendency for rust to form, but this can be avoided by placing a small quantity of oil in the cylinder.

Quarries operated by electrical power must be supervised with considerable care if accidents are to be avoided. Besides the mechanical risks there are a number of additional ones associated with the use of electricity. Quarries are usually located at some distance from central stations serving towns, and unless a generating plant is provided upon the premises, the electrical energy that is used must be transmitted from the more or less remote central station. The most economical method of transmitting electrical energy from a distance is by means of the high-voltage alternating current, transformers being installed at or near the utilization point to step down the voltage to the working value. It is very important to protect both men and machines against any break-down in the transformer, in consequence of which the high voltage on the primary line may be thrown into the secondary circuit. This is best accomplished by grounding the secondary circuit, provided an effective ground can be secured. A ground connection to a continuous water-pipe system is much to be preferred, but if such a connection is not feasible a grounding plate, box, or cone may be used, if care is taken to keep the ground resistance low.

It is often necessary to use extension cords to transmit power temporarily to points somewhat remote from the permanent wiring. Even under ordinary usage the protective insulation on these extension cords deteriorates rapidly, the rough stone surfaces over which such a cord extends, together with cuts from falling or rolling stones, shortening the useful life of the insulation, often to a surprising degree. Extension cords should be carefully, thoroughly, and frequently inspected, and all defects that may be discovered should be remedied before a cord is again put in service.

In circuits carrying potentials above 200 volts, reliance should not be placed upon insulation alone. When such circuits must be installed at points where workmen might come in contact with them, they should be inclosed in grounded conduits, or should be isolated by barriers or by elevation. The practice of scraping off part of the insulation of permanent wires in order to provide contact points for extension cords should be absolutely prohibited.

Under the general subject of transportation we may consider loading, haulage, and hoisting. In quarries where blocks of stone are loosened by blasts there are usually many small pieces to be loaded into quarry cars by hand. The larger pieces must be loaded on cars by movable hoists or derricks, and transported to the main hoist or derrick. Wire-rope slings, chains, and grab hooks are employed to attach the blocks of stone to the hoisting apparatus, and the grab hooks are the least dependable of the three. Unless the block that is to be loaded is carefully balanced it will tip and thus break the hold of the hooks. Flaws or unnoticed fractures may cause the stone to part under stress, and thus endanger the workmen beneath. Holes are sometimes cut for the grab hooks, but unless the work is carefully done they may prove to be an added danger. Holes cut too deep cause the bend of the hook to exert undue pressure on the edge of the block, so that even sound stone will sometimes chip off.

A chain that is wound completely around a block is somewhat safer than grab hooks, because there is little danger if the chain is sound and is properly placed. The principal source of danger is the unknown condition of the chains. They are constantly subjected to severe strains and shocks, which at any time may weaken one or more links, and this condition may be discovered only when an accident occurs. If chains are used they should be cleaned and carefully inspected, and they should never be subjected to a tension greater than one-third of the tension to which they have been tested.

Wire-rope slings are better suited for this work than chains or grab hooks. They may be easily manipulated and quickly adjusted to permit balancing the load. Worn or defective wires are easily detected, except when they are near the center of the rope, and the fracture of a few wires or even of a whole strand does not necessarily mean a sudden breaking of the whole sling and the falling of the load, as is the case when a chain link breaks. It is not advisable, however, to allow the use of slings that are excessively worn, or that have a number of broken wires. Slings of this kind should be permanently withdrawn from service, though they may sometimes be safely used for light loads. The greatest care should also be taken to prevent the use of slings that are too short, whether chains or wire ropes are used.

The haulage road for the stone cars in the quarry itself, and also the road leading from the quarry to the finishing mill, should be well constructed and kept in safe operating condition. It is often necessary to transport heavy loads on steep grades, and in such cases heavy rails firmly secured to cross ties are essential for safe and continuous operation. The quarry cars should be of substantial construction, and extreme care should be exercised regarding the efficiency of the brakes. This is an exceedingly important point in quarries where grades prevail, because the failure of a brake at a critical time may prove disastrous.

Accidents frequently occur from the use of hand tools, not because the use of such tools necessarily involves dangerous work, but rather because of carelessness and a lack of what may be termed applied common sense.

Hand or power-operated hoists of various types are extensively employed in and about quarries. It is important that careful and thorough inspections be made of all ropes, cables, slings, sheaves, hooks, and other parts of the apparatus. Any parts that are found to be excessively worn or otherwise defective should be renewed immediately. When replacing worn or defective parts, care should be taken to see that each new part is so proportioned as to be capable of safely withstanding the stresses for which the original part was designed. Unsuitable parts are often pressed into service temporarily, and the fact that they were meant to be used under certain restrictions and for a limited time is likely to be forgotten until an accident occurs. All exposed gears should be guarded, and adequate braking facilities should be provided. Hoisting cables that pass (either vertically or horizontally) within reach of the workmen should be inclosed or otherwise guarded.

The points just mentioned with respect to the safe and proper use of hoists applies equally well to derricks. As far as possible both hoists and derricks should be located at points beyond the possible range of falling material, or of flying fragments of stone from blasts. The hoist and derrick operators should be safeguarded by substantial sheds or inclosures capable of withstanding considerable shocks.

A simple yet adequate signal system is of prime importance as a means of communicating instructions to the operators of hoists and derricks. It may be feasible to depend upon shouted instructions when the quarry is first opened up, but when it has been developed to some extent the distance between the hoist man and the workmen, coupled with the noise from drills, channelling machines, and other sources, makes this method of communicating unreliable, and often utterly out of the question. Likewise, a signal system by means of gestures will soon prove inadequate, because in extended workings the signals must be repeated from man to man, or "relayed," because the hoistman often cannot see the work; and when the safety of the workmen depends upon bringing the load to rest quickly, the time consumed in relaying a signal may prove sufficient to cause an accident.

Nor must we forget the effect of smoke, steam, and fog on the correct interpretation of manual signals. If steam power is used to actuate the quarry machinery, smoke, steam, and fog, under certain atmospheric conditions, may create an impenetrable screen between the hoistman above and the workmen in the quarry. These same conditions may also prevent the quarrymen from noting descending buckets, boxes, or chains, until it is too late to escape from the danger.

On the whole, a bell system of signals will prove more satisfactory than any other, from the standpoints of both efficiency and safety. The signals should preferably be operated by electricity, though the bell-pull system has been installed in many quarries and often proves eminently satisfactory. Whatever signal system is used, it is exceedingly important to have a careful and competent man in charge of it. He must be able to correctly judge the speed of a descending or swinging object, the time that will elapse between the giving of an order to the hoistman and its execution, and the distance an object will travel after the hoistman has started to execute the order. This man should also see that no dirt or rock is protruding beyond cars, buckets, or boxes; that the slings that are used are properly selected and properly adjusted; and that the load can be safely carried by the apparatus; and he should also supervise the safety work in general.

ELECTRICALLY OPERATED GRAVEL PLANT.

A number of contractors engaging in extensive road construction and street paving operations operate their own plants for producing the sand, gravel and broken stone needed for their contracts. An installation of this kind is shown in the accompanying illustration. The view shows the old plant of the Northern Construction Co. of Elkhart, Md. Since the photograph was taken the plant has been electrified. It is now being rebuilt in another location and a new mast and new bins will be constructed. The present equipment will be used at the new location.

The digging machinery is of the loose line cableway type, the bucket, sheaves and practically all of the equipment being obtained from Sauerman Brothers, Chicago. The electric hoist was purchased from the Thomas Elevator Co., Chicago, and the revolving screens from T. L. Smith Co., Chicago. The small stone crusher operated in connection with the plant to crush the over-size is run by a 20 H.P. motor. A 5 H.P. motor runs the screen and a similar capacity motor operates the pump to furnish water to separate the material.

Old Sand and Gravel Plant of Northern Construction Co.

Regarding the charge of operating power Mr. G. C. Berkey, manager of the Northern Construction Co., advises us as follows:

> When we equipped our plant [illegible] doubled our output and used practically [illegible]. However, the [illegible] did not have [illegible] as they did when we were using steam for the hoist. We had to use gas engines for our screens and a gas engine for our pump, and we always were having more or less trouble with both gasoline power and the steam power [illegible] We are quite certain that our repair bills and our labor bills were all less, and our current or fuel bills not any more.
>
> Our daily output with our ¾-yd. bucket and teams was probably [illegible] 1-yd. bucket we could pull out 406 yd. a day with a great deal more convenience and a great deal more satisfaction and a good deal more certainty of a good, steady run, whereby our teams that were hauling material away from the plant [illegible]

SAND AND GRAVEL PRODUCTION ON THE JOB.

In the construction of a reinforced concrete building at Waterloo, Ia., the length of haul and cost of production for the sand and gravel used on the work were cut down by the installation of a semiportable dredging plant near the job. The arrangement is shown in the accompanying illustration. The dredging plant consists of a Sauerman drag-line cableway outfit with ¾ yd. bucket. The power is furnished by a 24 H.P. Lidgerwood engine. The main track cable is 1½ in. in size and the drag cable ⅞ in. The sand is dumped directly over three sets of screens and is immediately separated by gravity into two piles, one for fine sand and the other for coarse sand. The rock passes down the chute and into a crusher. The plant has a capacity of 250 cu. yd. a day.

The material is being used in the construction of a 5-story and basement 83x136 ft. reinforced concrete cold storage building. This structure is shown at the right in the photograph.

Dredging Plant Producing Sand and Gravel for Use in Construction of Concrete Building.

An Insley spouting outfit complete, with ½-yd. skip and yard hopper is being used to place the concrete. The power for this is supplied from a 16 H.P. Byers engine located in the small engine house shown to the left of the tower. A small Byers engine is used to operate the brick hoist. The mixer used on this work is a Polygon No. 1 manufactured by the Waterloo Cement Machinery Corporation. The Blackhawk Construction Co., Waterloo, Ia., is the contractor.

MOTOR TRUCK MOBILIZATION FOR THE MEXICAN OPERATIONS OF U. S. ARMY.

In the report of the Quartermaster General of the U. S. Army for the fiscal year ended June 30, 1916, considerable space is devoted to motor truck operations in connection with the Mexican troubles of last year. The following notes regarding this matter are of some little interest:

The first motor truck for carrying supplies was procured by the Quartermaster's Department in June, 1907, since which time the Quartermaster's Department has made constant progress in developing the motor truck as a means of transportation. Appropriations for this purpose, until recently, have been very limited. The progress of development, however, considering these circumstances, has been very satisfactory. The Quartermaster's Department first took up the matter of operating trucks seriously in 1911, and extensive experiments and observations have been made annually since that time. Near the close of the fiscal year 1916, however, extensive opportunities were afforded for determining the value of motor transportation under severe conditions in connection with the operations in Mexico and along the Mexican frontier.

The first specifications of the Quartermaster's Corps were written in 1913, after extensive correspondence with manufacturers and the Society of Automobile Engineers. These specifications have been revised and brought up to date annually. The revision of 1916 was carefully prepared in consultation with the Society of Automobile Engineers, which has given this department valuable and much appreciated assistance in solving the problems of motor transportation.

In this connection it may be stated that it is very difficult for motor-truck manufacturers to immediately effect changes to conform to the requirements of military trucks, for the reason that orders for materials are placed many months in advance of the time when it is required to enter into the manufacture of trucks.

During the early part of the fiscal year 1916 motor transportation was confined to operation of motor trucks in connection with the transportation of supplies between base depots and outlying camps on the Mexican border, in connection with the operation of Quartermaster Corps depots, and at a few posts in the United States and oversea possessions where motor transportation could be installed at a saving over animal-drawn transportation. By careful observations and such experiments as could be undertaken with the limited funds appropriated for procurement of motor transportation experience of great value was obtained, demonstrating that motor transportation can be relied upon under severe road conditions. Tentative organizations and regulations for all motor units, repair shops, and subsidiaries were prepared in the office of the Quartermaster General and distributed to those charged with handling these units, so that necessary steps were taken, so far as it was possible for this office to do so, under these new conditions.

When instructions were given for the organization of an adequate military force of troops to cross the Mexican border in pursuit of the Mexican band which attacked the town of Columbus, N. Mex., and troops there on the morning of March 9, 1916, the Quartermaster's office was in position to take immediate steps to procure necessary motor transportation which it was foreseen would be required. On March 11, 1916, the first call was received from the Southern Department for two motor-truck companies, consisting of 27 motor trucks each, of 1½ tons capacity, equipped with necessary personnel for their operation. As soon as the approval of the Secretary of War was received these trucks were purchased and provided with the necessary personnel, hired at the factories at which the trucks were manufactured. The personnel conformed to the organization above referred to. The two motor-truck companies first ordered left the region of the Great Lakes at 12 o'clock midnight, March 15, and early on the morning of March 16. Both were sent by special train service to Columbus, N. Mex. Two additional truck companies followed soon thereafter, as well as the necessary tank trucks for carrying gasoline, oil, and water.

It was soon found that motorcycles which originally accompanied these truck companies for carrying a certain portion of the personnel were unsatisfactory in operation over the heavy sandy country in Mexico where no made roads exist. Upon the recommendation of the local authorities light automobiles of the roadster type were substituted for use of motor-truck company commanders and truckmasters in lieu of motorcycles and have been found more satisfactory.

One of the most important features in connection with the operation of motor trucks is that they be equipped with a strong and suitable body. This is especially necessary where the roads over which they operate are rough and uneven. The body should be specially constructed and suitable for the work for which intended. Whilst the heavy body provided for in the specifications of the Qaurtermaster Corps adds materially to the weight of the truck, it more than makes up by its longevity and carrying capacity.

As the experience of the department becomes more extensive in the operation of motor trucks under the extremely severe conditions to be found in the operations in Mexico, many defects developed in some of the trucks in use; some of them of minor character, which could be easily corrected; others of a much more serious character. In general, however, it may be stated that the provisions of the specifications issued by this department were found to be based on correct principles for the service for which these trucks were intended.

The department has been greatly assisted by representatives of various truck manufacturers in the study of defects and recommendations for improvement in the motor transportation now in operation. By the end of the fiscal year 10 motor-truck companies, each consisting of 27 motor trucks of 1½ tons capacity, 6 motor-truck companies consisting of 28 motor trucks of 3 tons capacity, and 2 motor-truck companies each consisting of 33 motor trucks of 3 tons capacity had been purchased and were in operation along the Mexican border or en route to that point to be placed in operation. Of the above truck companies, 10 companies of 1½-ton trucks and 2 companies of 3-ton trucks were in operation on the line of communications which extended from Columbus, N. Mex., to San Antonio, Mexico, 301 miles from Columbus.

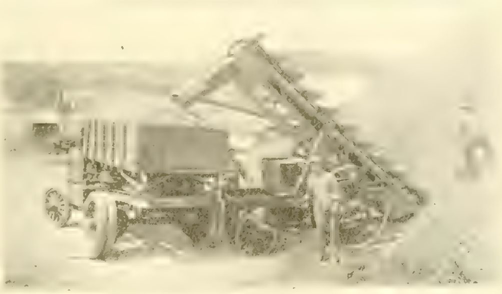
Upon the recommendation of the department authorities, Southern Department, a proportion of 3-ton trucks were supplied for use on the line of communications into Mexico, and at certain points along the Mexican border. At present there are 8 companies of 3-ton trucks in service in connection with troops operating in the Southern Department. Reports received up to this time indicate that these trucks are satisfactory in dry weather, but it is reported that during the rainy season the lighter trucks of 1½ tons capacity are more reliable.

From reports received it would appear that these truck companies were averaging somewhat more than 60 miles per day, in many instances as high as 80 to 90 miles per day, but due, however, to constant travel, the roads are reported to have become almost impassable. Steps were taken early in these operations to provide road machinery for necessary repairs to the roads. This work was done by the Engineer Department with funds and machinery furnished by the Quartermaster Corps.

From the time that the expedition went into Mexico to June 30, 1916, there were purchased for use on the Mexican border and with the expedition into Mexico 588 motor trucks; 57 motor tank trucks for carrying water, oil and gasoline; 10 motor machine-shop trucks for repairing motor transportation in transit; 6 motor wrecking trucks; 75 automobiles; 61 motorcycles; and 8 tractors for repairing roads, miscellaneous road machinery, repair parts, and equipment, amounting to $2,175,670.09.

HANDLING GRAVEL WITH LOADING MACHINE.

A large saving in the cost of handling gravel has been effected by the Goodyear Tire & Rubber Co. by the use of a wagon loader. The comparative test of this work by hand labor and by the use of the loading device showed the following results:



Haiss Digging Wagon Loader.

	Cost.
Hand labor.	
Loading wagons, 8 laborers, 3 yds., 1300 min. @ $0.25	$ .435
Loading auto truck, 8 laborers, 2½ yds., 1000 min. @ $0.25	.415
Cost of auto truck @ $1.00 per hour	.160
Cost per 5½ yds.	$1.010
Cost per yd.	.184
Wagon loader.	
Loading wagons, 2 laborers, 3 yds., 48 min. @ $0.25	.04[illegible]
Loading auto truck, 2 laborers, 2½ yds., 40 min. @ $0.25	.03[illegible]
Cost of auto truck @ $1.00 per hour	.066
Power @ ½ ct. per cu. yd.	.028
Oil, grease, interest on investment	.010
Cost per 5½ yds.	$0.177
Cost per yd.	.032
Cost per yard hand labor	.184
Cost per yard machine	.032
Amount saved per yard	$0.152

The above saving is entirely exclusive of supervision and overhead charges. The machine used in this test was the Haiss Digging Wagon Loader, which is manufactured by the George W. Haiss Mfg. Co., New York City.

A JET PUMP FOR HANDLING QUICKSAND.

Contributed by H. B. McDermid.

While sinking some caissons for foundation work that recently came to the writer's attention, some very troublesome quicksand was encountered. No centrifugal pump on the job would handle the mixture of sand and water, especially as the holes being sunk were too small to permit of the pumps being set close to the surface of the sandy water.

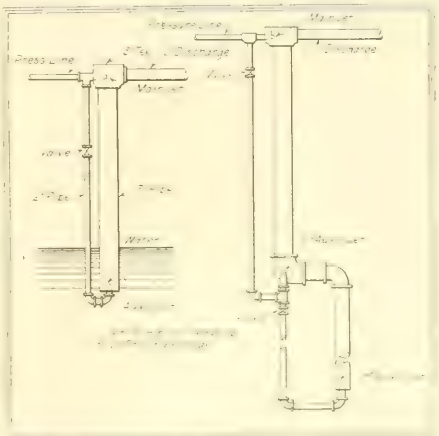
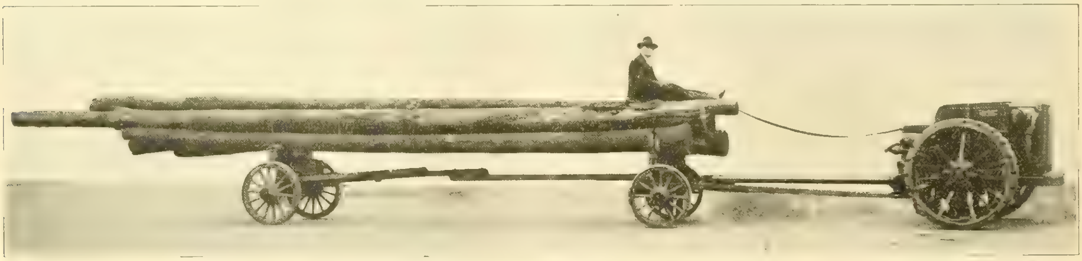


Fig. 1—Single Stage Jet Pump for Heads Up to 20 ft.
Fig. 2—Two Stage Jet Pump.

In these days of war rush orders, a regulation centrifugal "sand sucker" pump could not be obtained quickly, and had one been at hand it could not have been readily set close enough to the water, so that the suction head would come within the working limits of the pump. As the work was in a tremendous rush (being electric power plant work for which a great city waited in darkness) the superintendent of construction decided to use a form of jet pump, to be made of pipe and fittings already on the job. As the usual type of jet pump would not lift the suspended sand, he added a second as shown in the sketch. The main body of the pump was made up of 3-in. pipe and fittings, while 1 to 1¼-in. was used for the jets. No particular attention was paid to pipe lengths, the ordinary mill lengths being used. One length was employed for the single stage, and where the holes to be unwatered were too deep to be reached by a single length of pipe, a two stage pump was used with two jets as shown in Fig. 2. Pressure was supplied by centrifugal pumps operating through the regular construction piping system. It was found that pressures of 100 lb. or more were necessary for successful and satisfactory operation. However, when those pressures were applied, sand and water were sucked up rapidly and in a thoroughly satisfactory manner. These pumps were used for this class of work almost exclusively, on a $3,000,000 job, wherever there was an excavation to be unwatered, their simplicity and portability and the ease with which power could be applied, adding to their effectiveness.

A TRACTOR THAT "DRIVES LIKE A HORSE."

A tractor that permits the operator to ride his load is illustrated below. This is known as the Line Drive Tractor. It is line controlled machine. The mechanism by which this object is accomplished consists of three clutches and a brake. The main clutch applies the power of the motor to the driving wheels. The other two clutches by means of a suitable set of gearing, turn the front of the tractor which contains the driving mechanism, to the right or to the left, respectively, as one or the other of these clutches is engaged; they are disengaged automatically by a spring. A special automatic stop is provided which disengages these clutches in spite of the pull exerted on either line, before the drive wheels come into contact with the drawbar. The backing up is accomplished by means of a brake and a set of planetary gears. The tractor has a 4-cylinder motor and uses either gasoline or kerosene as fuel. It has a forward speed of 1 to 4½ miles per hour. Its weight, exclusive of water and fuel, is approximately 5,400 lb., and it has a rated brake horsepower at normal engine speed of 25. This tractor is manufactured by the Line Drive Tractor Co., Milwaukee, Wis.



Tractor That Permits the Operator to Ride His Load.

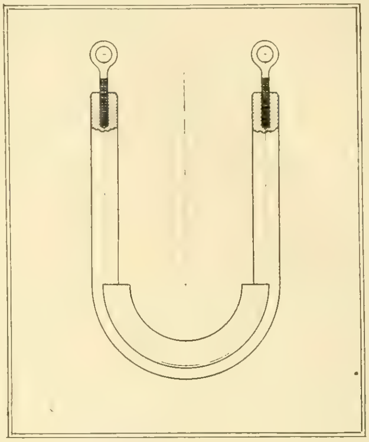
METHOD OF REPAIRING BROKEN U-BOLT IN STEAM SHOVEL.

The following method of making steam shovel repairs is given by Mr. P. J. Keating, Chief Engineer, Barr Clay Co., Streator, Ill., in the May Excavating Engineer.

All U-bolts upon their receipt and before being placed in stock should be drilled and tapped to receive a ⅝-in. eye-bolt, the outside dimensions of the eye being slightly less than the inside dimensions of the U-bolt nut, through which it passes.

To each eye-bolt is spliced about 30 ft. of 7/16-in. Samson spot cord. This cord is knotted every 3 ft. of its length in order that it may be securely grasped when very greasy.

If the U-bolt saddle block and cap have fallen to the ground, the dipper arm is levelled up and the saddle block cap is hoisted into position with a ¾-in. manila rope tackle. When the U-bolt nuts have been located on the slide plate, each eye-bolt is lowered through its nut and slide plate hole, down along the saddle block groove to the ground. It is then screwed into the U-bolt in the bottom of which rests the lower half of the saddle block bearing cap.



Method of Tapping U-Bolt.

Two men now raise the U-bolt through the slide plate and a third man passes a 4x4x10-in. stick over the engine and under the U-bolt, holding it securely while the nuts are screwed down. The lever is needed only to rest the men raising the U-bolt as the nuts are in position to be screwed home.

PERSONALS.

A. C. Clarke, heretofore chief of the facilities bureau of the commercial development department of the Baltimore & Ohio R. R., has been appointed Assistant Engineer of Surveys.

Mr. Guy Robert Ramsey, Assoc. M. Am. Soc. C. E., of Orlando, Florida, has joined the engineering staff of the Dunn Wire-Cut Lug Brick Company of Conneaut, Ohio, and will be Division Engineer for the Southern states, with headquarters at Atlanta, Ga.

John F. Stevens, Consulting Engineer, New York; John E. Greiner, Consulting Engineer, Baltimore, Md., and Henry Miller, former President of the Wabash R. R., are members of a special commission appointed by President Wilson to go to Russia to help reconstruct the transportation system of that country.

Ralph Volpe has been appointed Road Superintendent of Huntington County, Pennsylvania, succeeding D. A. McCloskey, who has been appointed chief of construction at Hollidaysburg, Pa. Mr. Volpe has been with the State Highway Department for nearly four years and has risen from rodman to his present position.

John H. Gregory announces that the firm of Hering & Gregory, Consulting Engineers, 170 Broadway, New York City, was dissolved on April 30th. Mr. Gregory will continue his practice as a consulting hydraulic engineer and sanitary expert at the above address, and will give especial attention to the subjects of water supply, water purification, sewerage, sewage disposal, and garbage and refuse disposal.

Thomas E. Dempcy of East St. Louis has been appointed chairman of the State Public Utilities Commission of Illinois. Mr. Dempcy for the past eleven years has been in the State's service as Assistant Attorney General, seven years under Attorney General William H. Stead, and four years under Attorney General Patrick J. Lucy. Fred E. Sterling, chairman of the Republican State Committee of Rockford, Illinois, has been appointed by Governor Frank O. Lowden as a member of the State Public Utilities Commission of Illinois, effective July 1, 1917.

Building and Structural Issue
of

Engineering and Contracting

Halbert P. Gillette, *President and Editor.*
W. H. Fogerty, *General Manager.*

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WILL WAGES FALL AFTER THE WAR?

There is a tendency to regard the present rates of "war wages" as being merely temporary rates that will recede to the former level shortly after the world war ends. Without doubt the prices of some materials, copper and steel, for example, will drop, but he is no student of wage rates who predicts a similar drop in wages.

Curves of wage rates have never followed curves of market prices, rising and falling with every tide of demand. Wages, it is true, have risen as a whole when prices as a whole have risen, and occasionally, but not always nor to so marked a degree, wages have receded as a whole when average prices have gone down. But wage-earners are prone to cling stubbornly to every increase, and ultimately to maintain nearly all, if not all, of the increase. This has been notable in the industries where labor unions are powerful, but it has also been conspicuous in other industries. Increased wages of course can not be permanently maintained unless there is increased output of the workmen. But increased output is one of the things that high wages beget, and this comes about in two major ways: First, through the efforts of the employer and his managers to increase the efficiency of high-priced workmen. Second, through the efforts of the men themselves to "make good."

It has long been known that the higher priced workmen of the Pacific Coast were the most efficient workmen in America; but it was reserved for Henry Ford to show in a spectacular manner that a $5 minimum wage would serve to speed up shopworkers farther east to an unprecedented degree. There is a vast deal of "bunk" along with some truth in the common statement that "high wages breed inefficient workmen." For the most part, this is not true, and it is rarely true where the employer takes pains to arouse the workmen's ambition and to cultivate his good will at the same time.

The workmen of Europe are receiving higher wages than ever before, and they are also delivering more units of product per man-day than ever before. They, too, will not go back to lower wage rates, for they, as well as their employers and their governments, have learned a lesson. This, in its turn, will assist in keeping up the wage rates in America.

Higher wage rates are here to stay, at least until they go still higher. He that defers construction until there shall be a marked fall in wages will never construct anything.

The conclusions to be drawn by managers of public and private enterprises are these: Go ahead now with every project that will return an adequate saving or profit in normal times. Aim to secure minimum unit costs by careful design, by the rise of labor-saving machinery and by vigorous driving of project to a finish. It is not overstating matters, we believe, to assert that if the best of present designs were substituted for the present average design, fully 25 per cent of the cost of materials can be eliminated. This can be effected in some cases by substitution of one kind of material for another kind; but in most cases it can be effected by a better use of the materials now used. The average output of workmen is susceptible also of fully 25 per cent betterment merely through better management. But, in addition, the more extensive use of labor-saving machines and devices can be counted upon to secure a still greater reduction in unit costs.

For the moment, unit construction costs are relatively high, and some of them may long remain at the present level. Mere passivity, however, will not reduce them. High wages are here to stay. Whether lower unit costs are to be attained is distinctly "up to us"—the engineers and contractors. And we can not attain them by waiting. They are attainable only by the exercise of our wits. The time for that exercise is now. Engineers should encourage their clients and employers to go ahead with projects that would normally be put through.

HABITS VS. KNOWLEDGE.

Pedagogues and practitioners have never ceased wrangling over the subject of engineering education. Probably they never will be in general accord as to the details of educational methods, but surely the subject is not so abstruse as to prevent substantial agreement as to the general conduct of the training of engineers. Most of the wrangling could be silenced temporarily, at least, and perhaps forever, if actual tests of two diverse educational theories were made under competent observers and upon a fairly selected and sufficiently large number of students.

The mind is a very complex organ, and its growth along desirable lines is hardly to be predicted upon a priori reasoning. Thus it is scarcely safe to infer that because the discovery of general laws of physics and chemistry has vastly aided the progress of science, the training of students should consist mainly in familiarizing them with general laws and their varied applications. Yet that is the hypothesis upon which many an educator has builded his system of instruction. On the other hand, it may not be safe to reason from the professional successes of men whose early training has been in the details of a profession, that it is preferable to approach the study of engineering as did the men who began as apprentices to engineers.

If one relies upon the evidence of successful engineers as to what educational methods lead to success, one may infer that any method will serve, provided it is applied to the right sort of a brain. The problem at bottom is a problem in economics, and it therefore can not be solved until we have comparable quantitative data. This leads to the conclusion that until we know what per cent of highly efficient engineers—as judged by subsequent success in practice—each method of training produces, we really know very little at all about the effectiveness of different systems of engineering education.

Upon one general principle of education most engineers, whether teachers or practitioners, are agreed. namely, that the object of an education is to teach men how to think rather than to teach them a mass of facts. Yet, although there is agreement on this point, may it not be questioned whether the agreement is wholly justified? Consider, for a moment, that an alert, young mind is scarcely capable of learning facts without asking itself questions about them. The mere seeing of many phenomena suffices to arouse such a mind, to cause it to reason about them. Travel is generally conceded to be an education in itself. Why is it so, unless mere seeing begets thinking and acting in a more effective manner?

Consider, also, the significance of the fact that the learning of general laws and their applications, as commonly taught, fail to arouse interest in many students. Certainly any educational method that fails to kindle the interest and ambition of a young man is far from being a satisfactory method. And we may talk till sunrise about the importance of learning these general principles and still have reason to talk on, if the men who have learned them are not keen to move forth on their own initiative.

Even the old argument that the main object of an education is to produce thinkers is open to question, for there are thousands of easy-chair thinkers who have been thus trained, men who reason well yet achieve nothing noteworthy in a whole life of fine reasoning.

Should not the fundamental object of all technical education be this: First, to kindle the ambition, then to feed it a fuel of usable facts, and finally to inculcate habits of marathon thinking and persistent acting until a definite goal has been reached.

These hundred-yard dashes in mathematics, applied mechanics and pure science, such as most colleges give, do not constitute the sort of habit formation that men most need if they seek subsequent success, which will be granted even by those who teach in this fashion. But they will urge that post-graduate training must supply the long-distance tracks whereon the marathon runners will develop themselves. Yes, after life supplies the long-distance tracks, but it frequently fails to change the inground habits of the trained sprinter, who looks with no great favor upon distance events.

No, it is not a knowledge of general principles alone, nor of facts, nor merely of how to reason, that men should seek. The habit, deeply ingrained, of searching for facts and principles in the face of long-sustained effort, is, we believe, vastly more desirable than any given kind of knowledge. The habit of acting so as to employ usefully any knowledge that has been gained is scarcely less important than the habit of search. In other words, the thinker must be habituated to be a man of action.

But can habits of this sort be acquired at college? Working upon the plastic minds of men 19 to 23 years old, if habits of any sort can not then be formed, there is small chance that they ever can be formed. Not a few college students form such habits in themselves, and with full consciousness that they are forming them. It can hardly be urged, therefore, that young men can not be habituated at college to think and act as they must act in after life if they are to be leaders.

"MY ADVICE TO EVERY BUSINESS MAN IS——"

Henry Ford.

In a recent magazine article Henry Ford said:

> My advice to every business man is to read a lot and think a lot and work a lot

There is more real substance in this bit of homely exhortation than in most of the verbose adjurations with which "scientific managers" attempt to teach increased efficiency.

"Read a lot." How many engineers and contractors do it? 'Fess up. Don't you think you "read a lot" if you spend an hour a week reading engineering periodicals and books? Is that "reading a lot" in the Ford sense?

"Think a lot." Having "read a lot," having seen how others have solved problems similar to yours, the next step is to "think a lot" about those solutions. How many of us do it? Aren't we given, rather, to doing most of our thinking on the spur of the moment? Don't we incline to trust largely to our supposed ability at solving problems speedily when we are faced with them suddenly in the field or office? And, to go a bit deeper into self-catechism, are we not a bit distrustful anyway about what these book and paper writers tell us they and others have done? Isn't there more than a bit of the snob in our attitude toward all writers? Isn't the average "doer" —as he likes to call himself because he seldom reads or studies—isn't the average "doer" somewhat inflated with the importance of his activity and given to look with condescending superiority upon the author tribe?

Evidently, Henry Ford is not, and what he is not is well worth the study of any man. He bids us "read a lot and think a lot." Then he winds up with, "and work a lot." This last element of his advice probably needs no emphasis, for the average engineer or contractor is anything but shiftless or visionary. He is apt to be a worker. What we do question is whether he is so apt to be a reader.

One would think that at least those engineers who have had a college training would be habituated to reading a good deal, but are they? The editor has been repeatedly struck with the significance of the fact that few engineers have much of a technical library. Most of them hobble along with a baker's dozen of up-to-date books, and seem to regard such a possession a sufficient guarantee against being charged with bad habits as to reading. Nor is it the high price of technical books that accounts for this prevalent attitude toward them. Even the large libraries of engineering societies are visited infrequently by most of the engineers in reach of them.

Not long ago the editor met a young Pittsburgh merchant, one of the "live wires" of that very live industrial city, and he asked this successful man the old, old question: "To what do you attribute your success." Instantly he replied: "Reading, traveling, and action." Elaborating this trio of activities, which somewhat resembles that recommended by Ford, he proceeded to say that the reading of trade and business periodicals occupied him fully ten hours every week, often much more. An equal amount of time was spent in traveling, although with not the same regularity as in reading; his traveling having for its sole object the interviewing of other merchants as to their methods. He said:

> When I go to a city that's new to me I begin by asking people what is the best hardware store in town. I soon learn, and I go there. I tell the proprietor that his is voted the best hardware store in the city. Being a hardware merchant myself, I know that it is no accident that has made him a leader, so I have come to him for advice. I ask him what is the best thing he has "put across" recently. He tells me that, and a lot more. I tell him a few things that have worked well with me, show him some photographs of windows and interior displays, and tell how each of my five delivery cars has a fireless cooker mounted over the hood as an ad. Does my visit pay? It never fails, to pay. I read, I travel, and I act upon the knowledge thus gained.

How many of us travel even to a nearby job to learn how it is being handled? How many of us make a practice of attending conventions and "shows" to pick up information? Candidly, have not most of us a real lesson to learn from Ford's simple and plain advice?

THE COMPARATIVELY SMALL PROFITS OF THE RAILWAYS.

In round numbers the net earnings of all the steam railways in America were a billion dollars for the year ending June 30, 1916. A big sum, to be sure, but barely sixteen times bigger than the profits of the Ford Motor Car Co. for the same year!

It is claimed by the railways that their billion-dollar "profit" for 1916 was only 6 per cent on the value of their physical property. It is certain that it was not greatly, if at all, in excess of 6 per cent, for enough railway mileage has already been appraised by public commissions to demonstrate this much at least.

The railways are asking a 15 per cent increase on freight, and probably will be granted a substantial part of their request—at least enough to meet higher operating expenses. Even so, consider how small-minded the American public remains in its treatment of a great industry having a gross income of three and a half billion dollars, and an investment of five times that sum. The public has done its best to squeeze the life out of our railway systems for more than ten years past, and has called the process "squeezing the water out of railway stocks." Yet the same public that has taken ten years to come to sane treatment of the railways, and even yet has not "arrived," takes less than four weeks to appropriate for war a sum of money that is almost half the total capital invested in our railways! What magnificent spenders we magnificent quibblers can be! A decade of quibbling has not taught us a far-sighted generosity in dealing with railway capital, yet between two full moons we decide to tax ourselves enough to reproduce nearly half the railways in this country!

Of course there is a vast difference between the two issues—railway rates and war. But is there such a vast difference as to justify endless quibbling about the one and precipitous action about the other?

We all see, now that war is upon us, the truth in what the late James J. Hill and other railway presidents told us many years ago, that a billion dollars a year should be spent in new terminal and track facilities and rolling stock, to provide adequately for the growth of traffic. They also told us that the new capital could not be secured under the restrictive regulation of rates that was in vogue. They were right in both predictions. But did we even so much as try to ascertain the basis for their statements? Not a bit of it! It was so much easier to call them self-interested advocates than to inquire whether their self-interests were not in fact a matter of interest also to the entire nation.

Now here we are with a war upon us, and inadequate transportation facilities for the peak load that war begets. Capital refuses to flow into railway stocks, yet flows rapidly enough into other channels—automobile factories, for example, where one concern that employs some 30,000 men, shows more annual profit than a railway system that employs four times that number.

LET ENGINEERING STUDENTS FINISH THEIR COURSES.

There is a steadily growing feeling that engineering classes should not be broken up because of war. We are glad to note that at least two engineering periodicals voice this sentiment.

Chancellor Brown of New York University has advised engineering and medical students to finish their courses, the engineers to take military tactics as part of their curriculum.

There are about 10,000,000 men between the ages of 21 and 30, of whom less than 17,000 are taking courses in engineering colleges, or one in 600. About an equal number of engineering students are below the age of 21. As operators of machine guns or users of rifles, these partly trained engineers would be no more effective than men entirely without engineering training. As graduate engineers, however, they will be vastly more useful to the nation.

If the war is to be short, these undergraduate engineers will be of little or no use as engineers in the war. If it is to be long, their usefulness after graduation will be great, particularly if during the remainder of their course at college they are required to study the principles of military engineering.

Already many engineering students have enlisted in the officers' reserve corps, and are not only continuing their regular engineering studies, but are studying military engineering. In addition they are spending their recreation hours in physical training under military instructors. Engineering students at Yale were among the first to volunteer for this strenuous double duty.

More than once in past years has the editor of Engineering and Contracting urged engineering colleges to pattern after West Point in certain respects. The wisdom of that advice is now apparent, but advice that was not heeded in peace times takes a new aspect in times of war. Even after this war ends it is altogether likely that most of the State universities will require their engineering students to undergo a physical training not unlike that given at West Point.

EDITORIAL COMMENT.

High wages make machines necessary, and machines make high wages possible. Here, as in many other fields of human activity, there is a veritable cause-effect circle, nor is it a fallacious "reasoning in a circle" either. The existence of high wage rates itself acts as a reason for seeking to reduce unit costs by the use of machines. Then the use of machines, by increasing the output of men, makes possible the continued payment of high wages.

Is there any real scarcity of labor in America? Isn't the real scarcity a scarcity of knowledge and wits? When the editor sees most farmers still using one and two-horse teams and a single-share plow, instead of using a "six-up team" with a gang plow, he knows that here is an ignorance that is costing the country dearly at the very time when labor must be economized. When he sees brick buildings being erected without the use of so much as a mechanical mortar mixer or a small hoisting engine, he knows that the farmers are not the only class ignorant of many economic aids. When he sees basements dug by hand, although they are large enough to warrant the use of a small steam shovel, and when he sees the earth hauled away in 2-yard loads, with two horses instead of 4-yard loads with four horses or a motor truck, he knows that his own job as an editor is not yet drawing to a close because of lack of audience.

Frank B. Gilbreth invented a "fountain trowel" that enables brick masons to increase their output considerably. He invented a "pocket" for handling bricks economically in transit to the brick mason, and one of whose important incidental advantages is that it can be used to record exactly the number of bricks laid by each mason each day. These and several other things of proved merit are described fully in his book on "Bricklaying System." Yet, go where you will, whom do you see using these labor-saving methods? Brick masons are scarce, we are told. Not a bit of it. What is scarce is a prevalent knowledge of how to secure a greater daily output of brick laid, and a determination to put that knowledge into use.

In "dynamic Detroit" they erected $51,000,000 worth of buildings last year, or three times the amount erected in 1910. The present year promises to outstrip last year in building operations in "the home of the motor car."

The Supreme Court of Illinois has ruled that a corporation may act as an architect, provided it employs a licensed architect, in spite of a section in the architect's license law prohibiting a stock company from practicing architecture.

The Bethlehem Steel Co. is building a city to accommodate 55,000 people at Sparrows Point. The sparrows plan to nest in the eaves before the year is over.

More than one engineering and contracting firm has recently taken up ship building. Sanderson and Porter of New York, and the Foundation Co. of the same city, have large government contracts for wooden ships. The Traylor Engineering Co. of Allentown, Pa., has also entered "the shipbuilding game."

Contractors will find many construction opportunities in the building of the cantonments for the U. S. Government. In all 32 mobilization camps are to be erected for the new army of 1,000,000. Each of these camps will be a complete city in itself, capable of providing for about 22,000 soldiers. Each camp will contain about 2,000 wooden 1 and 2-story houses. Over 600,000 M ft. of lumber will be required for this work alone. Plans have been made and as soon as the sites are selected and surveyed the construction contracts will be let.

FIRST MANUFACTURE OF STEEL BEAMS AND METAL SKELETON CONSTRUCTION.

To the Editor: I was much interested in your very kind notice of the address which I delivered in the course of popular lectures, at the University of Pennsylvania. The Philadelphia newspaper, which printed brief references to my lecture, in one instance printed the date relating to the first manufacture of steel beams by the Carnegie Steel Co., 1895 instead of 1885, giving an entirely wrong impression of the character of architectural construction just at that time. This error was unfortuately repeated in your notice, and I have been accused of not being properly informed in regard to this detail.

In regard to the invention of the steel skeleton frame, I believe it is generally acknowledged that it was invented and first developed in Chicago. Professor Hamlin, of the School of Architecture of Columbia University, says, that this statement may be made despite the fact that in 1888 the late L. A. Buffington, of Minneapolis, patented a system of metallic skeleton construction which embodied many features of the present system. Most of these features, however, were not new; each had been used in earlier buildings in varying forms, and the so-called Buffington column was considered an unscientific laminated affair of flat plates, combined in ways which were wasteful and inefficient. Mr. Buffington was unable to carry to any successful conclusion suits for infringement against Chicago and New York architects. It was really Jenney & Mundie, the Chicago architects, who first put the conception to practical use, and I believe that today architects and engineers give this firm the credit for this design in all its essential features.

I wish to express my appreciation of the value to the architectural profession, as well as to engineers, of "Engineering and Contracting"; its monthly issue devoted to "Buildings and Structures" is of especial value to architects.

Thomas Nolan,
Professor of Architectural Construction, University of Pennsylvania.
Philadelphia, Pa.

DOUBLE GLAZING OF WINDOW SASH.

To the Editor: Seldom have your readers been given such an illustration of the difference in the viewpoint taken by an architect from that taken by an engineer, when discussing or considering the same subject, as will be found when comparing the letter written by Clarence A. Martin, dean of the College of Architecture, Cornell University, and published in your last Building and Structural edition, with the editorials, etc., from your pen, upon the question of the double glazing of window sashes, for the purpose of preventing the present enormous losses of heat and the consequent indefensible waste of fuel.

The chief aim of the architect has ever been chiefly confined to appearances, while that of the engineer has been "economic advantage."

I have read your article upon the "Double Glazing of Window Sashes" and upon the "Heat Conductivity of Building Material" with great interest, pleasure and profit. Your views I heartily endorse, the more so because I am expecting that during the next decade the cost of fuel will greatly exceed that current in the years just passed.

However, apart from the monetary savings that may so easily be effected, it does seem to me that no one should be permitted to waste fuel, even if the alterations necessary to prevent such waste may affect, to some slight extent, the appearance of a house or building.

The world's stored supplies of fuel will not last forever. The present generation should not be permitted to waste that which may be badly wanted by the next. Those who are so well endowed with this world's riches that they are able to employ the services of an architect, can probably afford to pay for the fuel they waste. Also they can, if they are so inclined, provide the windows of their houses with double sashes, which will reduce the waste, but the majority of citizens cannot afford the expense of double sashes, consequently double glazing, properly done, offers a suitable and less costly substitute.

Dean Martin appears to have taken some interest in the problem you have brought up. I suggest that he help to solve the following:

What difference in heat conductivity is there in and between the several different weights of common glass used for glazing the windows of houses, etc.? What difference is there in heat conductivity between the heaviest weight of common glass generally used and the lightest weight of plate glass? What difference is there in heat conductivity between the lightest weight of plate glass and the heaviest weight, as used in the most expensively constructed dwelling house?

Does the size of the panes make any difference to the total heat-loss from the same area of window?

What area of window is required by the requirements of sanitation to light a room of stated cubic contents?

Does the aspect of such window enter into the calculation?

Is it necessary or desirable, in the northern part of the continent, that the bottom sash be made to move up instead of being a fixture? If desirable, why desirable?

If the bottom sash be glazed with plate glass why should not the upper sash be double glazed with common glass, using small panes?

I am of the opinion that such arrangements of windows and of glazing might, in many cases, be adopted, and that without destriment to the appearance of the house. Further, I am of opinion that such an arrangement would be generally adopted were architects to advise their clients of the saving in fuel such an arrangement would ensure.

In conclusion, permit me to thank you for having drawn the attention of your readers to this most interesting and, I hope to find it, live study.

Louis Simpson.
Ottawa, Ont.

PAINT AS PREVENTIVE OF DRY ROT.

To the Editor: A member of this association has called my attention to an article which appeared in your issue of March 28, entitled "A Derrick Accident," containing the following sentence: "Painting the outside may hasten and not prevent this."

This struck my correspondent, and also it seems to me really to amount to technical advice against the use of paint.

From the researches made for us at the Institute of Industrial Research, at Washington, D. C., we all feel pretty secure in the belief that the aldehydes, etc., given off during the drying of paint are germicidal and fungicidal, and therefore are entirely unconvinced that dry rot is at all likely to occur under a coat of good linseed oil paint, especially if repainting be attended to at proper intervals.

G. B. HECKEL, Secretary,
Paint Manufacturers' Association of the United States.
Philadelphia, Pa.

THE FIRST STEEL BEAMS.

To the Editor: In the building and structural issue of Engineering & Contracting on April 25 appears an editorial on page 384 entitled "Who Invented the Modern Skyscraper," in which certain statements are made based on advices from Professor Nolan as to the manufacture of steel beams by the Carnegie Steel Co.

These statements are so erroneous that they should be corrected. You will note a discussion by me relative to the entire subject of metallic beams and girders in the

February, 1912, issue, "Proceedings of the Engineers' Society of Western Pennsylvania," page 10.

Carnegie, Phipps & Co., Ltd., rolled 12 and 15 in. steel beams in 1884. By 1889 the use of steel had been extended to include not only beams and channels but deck beams, bulb angles, tees and zees, and since 1892 the product of the Carnegie Steel Co. has been exclusively steel.

The first 12 and 15 in. beams were rolled at Upper Union Mills, Pittsburgh, in 1884. They were followed by the rolling of 20-in. steel beams at Homestead Steel Works on Jan. 3, 1888, by 24-in. steel beams at the same works on June 19, 1889, and by 18-in. steel beams at the same works on Feb. 3, 1897. The entire line of beam sections, with the exception of the 18-in. beam, was available in steel previous to 1890. Their use had been so developed through the United States and they were made by so many makers that the entire line of beam sections could be standardized and practice made uniform among all the makers by Jan. 17, 1896, which is the date of the final report of the Committee on American Standard Beam Sections appointed by the Association of American Steel Manufacturers. From that date the practice of American manufacturers which had grown up for 12 years along different lines became uniform.

R. B. Woodworth.

Pittsburgh, Pa.

METAL SKELETON CONSTRUCTION.

In the last Building and Structural Issue of Engineering and Contracting attention was called to the lack of definite information regarding the inventor of the metal skeleton type of building. Through the courtesy of Mr. Charles S. Frost, Architect, Chicago, we are enabled to reprint below the contents of a pamphlet that throws some light on this subject. This pamphlet was prepared by Frederick Baumann, and according to a memorandum written by him in October, 1914, it was printed in December, 1884. Mr. Baumann in his memorandum states: "My first work on this idea was a sketch for a building 50x200 ft., at S. W. corner of Clark and Jackson, Chicago, in 1883. But it was an idle task. Lot was sold and J. W. Root built in 1884 the very neatest building in our city, but not of iron construction. About 1½ years after printing this schedule an architect at Minneapolis got letters patent on the idea, but suing an owner for fees he lost his case when this paper was presented. The spirit of the American citizen then being foreign to me I neglected to apply for letters patent and thus forfeited a rich privilege"

The pamphlet prepared by Mr. Baumann follows:

IMPROVEMENT IN THE CONSTRUCTION OF TALL BUILDINGS

a. There is in life no exception from the laws of competition. It is proper, therefore, to view the matter of building in this light.

b. Occupants seek, convenience, secureness and light—all this, of course, combined with a shine of elegance.

c. The highest success in a happy combination of these four points will lead to the highest possible and most permanent rental.

d. Structures wholly composed of iron would in this light be the most preferable were it possible to clothe them with proper elegance, and were they proof against neighboring fires.

Hence my

CONCEALED IRON CONSTRUCTION OF TALL BUILDINGS.

1. The design is to erect a foundation, a firm and rigid skeleton of iron, and cover the same at once with a proper roof.

2. During the time of erecting such iron structure, or hull, from within, the enclosure—be it stone, terra cotta or brick, or any combination of these materials—may be erected from without.

3. But the within work would proceed much faster than the without work. While the hull may be roofed within two months, the enclosure might not have proceeded beyond the fourth floor.

4. No delay will be caused by this to a steady progress. Derricks may be set on the roof for finishing the outward enclosure in an easy and convenient way. Large, unwieldly and dangerous tall derricks are discarded.

5. During and at the same time the interior work would be pushed and brought to an end. The erection of partitions, fireplaces, vaults, arching of ceilings, and lining of exterior walls would be accomplished.

6. Thus all interior work would be done and made ready for plastering during the time required for accomplishing the exterior parts.

7. This process would make the work far more independent of weather than is the usual process. The erection of the iron hull is, in its nature, a rapid process.

8. The practicability of erecting buildings on Chicago soil twelve and more stories high becomes a fact.

9. Light, the most indispensable desideratum with a building, is procured even in the lowest, most valuable stories, where otherwise the necessarily broad piers would be a hinderment.

10. The piers may not only be made narrow, but shallow also—27 inches at the most; and this again is a saving of light.

11. The iron uprights are to be provided with a series of projecting brackets for the purpose of anchoring and supporting the parts forming the exterior enclosure.

12. These supporting brackets to be so arranged as to allow an independent taking out of any part or portion of the exterior lining which might have been damaged by fire or otherwise.

13. The iron floor girders are securely fastened to the outward posts at both ends. This imparts firmness to the structure. And, more, it enhances the bearing strength of the girders to at least one and a half times their usual strength.

14. The iron floor beams are fastened to the sides of the girders, and will gain thereby at least 20 per cent to their strength.

15. Vaults, partitions and fireplaces may therefore be placed upon the girders without increase to the dimensions of the same, and floor beams may be made lighter than usually.

16. This will enable the expert to save, on the substance of the necessary iron, enough to pay for the extra labor of riveting all parts.

17. A vault 4 feet by 5 feet within, built of porous firebricks, with walls 9 inches thick, without special (unnecessary) arching, but having light steel plates in its concrete floor and ceiling, will not weigh to exceed four tons.

18. A fireplace built against a partion of light hollow tiles, and with flues specially made of same (fireclay) material, will not weigh to exceed one ton.

19. Both vault and fireplace may therefore be built at any place, and in any story, upon a girder, without requiring even as much additional strength to iron girders as is gained by the riveting at both ends.

20. The extra cost of iron posts required in exterior walls will be, in an eight-story building, about offset by what is saved on masonry.

21. Buildings with more than eight stories would be—circumstances being equal—the cheapest with my new construction.

The above twenty-one points plead in favor of my "Concealed Iron Construction," and show it to be a saving in the four most important items in the construction of buildings, which are light, convenience, space, time.

Respectfully submitted,
FREDERICK BAUMANN.

BONDING STRENGTH OF PAINTED RODS.

Tests of painted rods for bonding strength with concrete have been made by the Boston Transit Commission of Boston, Mass. The paints were first given weathering tests and tests for action when in contact with alkali water, acid water, and sea water. The results of these tests were very varied, some of the paints failing badly to pass the weathering tests and the alkali water test, both of which tests should be passed by any paint used by the Commission.

For the bonding test, plain round ¾-in. steel rods were carefully cleaned and cut in 24-in. lengths. After being painted with the requisite coats of paint and allowed to dry for a proper time, the rods were embedded for 11-in. of their length on the long axis of concrete cylinders which were 12-in. long by 6-in. in diameter. The concrete was proportioned by volume 1 part of cement to 2 parts of sand to 3½ parts of broken stone (sized ⅜ in. to 1½ in.). The rods were allowed to set in the concrete blocks, undisturbed for two months. Three rods of each series were then pulled out of the concrete in a testing machine at the Massachusetts Institute of Technology, under the direction of Prof. H. W. Hayward, and the bonding strength of the painted rod with the concrete measured. Some plain, unpainted rods had been buried in cylinders and the bonding strength of the painted rods was found to be much less than for these. The best bonding strength of any of the painted rods was only about 1/5 that of the plain rods. The second best bonding was only about 1/6 that of the plain rods. The other paints gave bonding strengths between 2 per cent and 10 per cent of the plain rods.

Additional barracks to cost about $1,000,000 will be erected at Fort Benjamin Harrison, Ind. Contracts also will be let in the near future for 31 buildings to be erected at Fort MacArthur, near San Pedro, Cal.

GRAPHICAL ANALYSIS OF STRESSES IN COMPLEX COLUMN SECTIONS.

(Contributed by W. S. Wolfe, Instructor in Architectural Engineering, University of Illinois.)

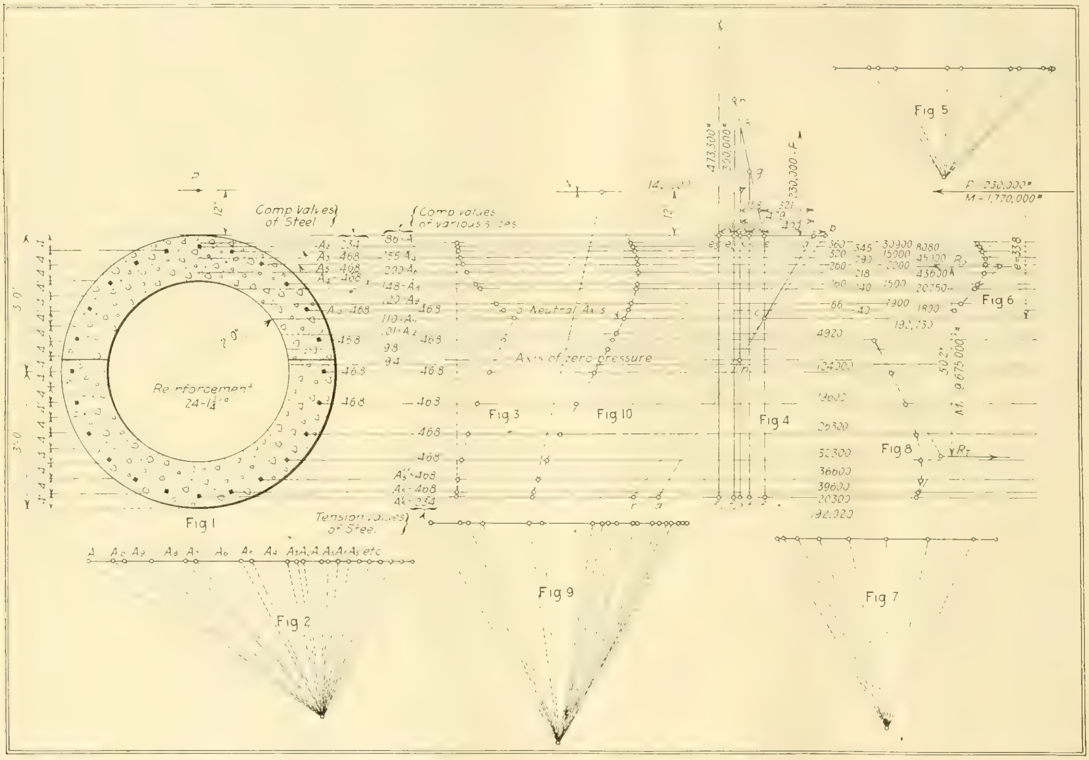
The following article might be considered as a continuation of the article on "Graphical Determination of the Stresses in Eccentrically Loaded Reinforced Concrete Column," which appeared on page 386 of the April 25 issue of Engineering & Contracting.

When the section of a reinforced concrete chimney, or any hollow circular section, such as shown in Fig. 1 of this article, is considered as having as eccentric load, we have a very difficult problem as far as an analytical solution is concerned. However, when the graphical analysis is applied, we find that the solution is comparatively simple, being but very little more complicated than the solution of a solid square column reinforced on all sides.

In Fig. 1 the concrete is divided into a number of small slices. From the approximate centroids of a number of these slices, on the compression side, lines are drawn to the right on which are shown the areas of the various slices, which areas may be called their compression values. Assuming that the concrete does not take tension, the tension value of each of these slices would be zero. From the steel rods lines are also drawn on which are marked 15 (n) time the steel area, which is the tension value of the rods and also their compression value. These tension and compression values are laid off in the regular way in the force polygon Fig. 2, from which the funicular polygon Fig. 3 is drawn, locating the neutral axis by the intersection 0. The base line (ef) in Fig. 4 is now drawn (eb), is made equal to 400 lb. per sq. in., for convenience, and the line (bcr) is drawn. From the intercepts between the lines (bcr) and (ef) and from the areas of the slices and rods the compressive forces and also the tensile forces are computed.

At this point it is desirable to make a check on the work which has been accomplished. We know that the summation of the compressive forces produced by a bending moment should equal the sum of the tensile forces, therefore by making these two summations and comparing the results a check will be obtained. This has been done at the right of Fig. 4 and the error found to be less than ½ of 1 per cent, which is satisfactory. The resultant of the compressive forces is now located by the force polygon Fig. 5 and the funicular polygon Fig. 6; also the resultant of the tensile forces is located by the force polygon Fig. 7 and the funicular polygon Fig. 8. From these results the effective depth is found to be 50.2 in. and the resisting moment, when the maximum stress in the concrete is 400 lb. per sq. in., is computed and found to be approximately 9,675,000 in. lb. The moment produced by the eccentric load P, which has been assumed to act 12 in. outside of the section and to have a magnitude of 230,000 lb., is 7,770,000 in. lb., which by proportion would produce a maximum stress in the concrete of 321 lb. per sq. in.

The effect of a direct load of 230,000 lb. at the neutral axis will now be considered; the base line (ef) is moved 100 lb. to the left, to the position (ef) and (eg), is computed and found to be 142,000 lb., which is equal to 15 times the area of all the rods times 100 lb., plus the summation of the area of each and every slice times the average increased compression over it. The base line is now moved 100 lb. farther to the left, to the position (e_2 f_2) and (e_2 h), is found to be 300,200 lb. In like manner (e_2 i) is found to be 473,300 lb. and the curve (eghi) is drawn. K is now located so that (KX) equals P equals 230,000 lb. and the true base line (XY) is obtained giving (Xa_2), the total maximum stress in the concrete, equal to 158 + 321 = 479 lb. per sq. in. The intersection of (XY) with (ad) gives n which locates the axis of zero stress. The maximum stress in the steel is (rY) = 710 × 15 = 10,650 lb. per sq. in.

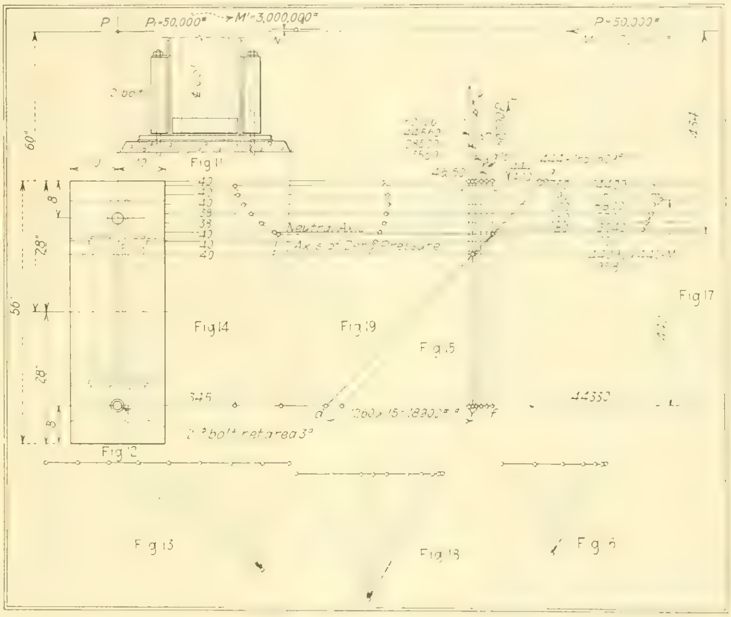


Figs. 1-10—Graphical Analysis of Stresses in Complex Column Sections.

Graphical Check—The intercepts between the line (ad) and (XY) times the various areas will give the resisting forces produced in these areas by P. These forces were found and laid off in the force polygon Fig. 9, from which was drawn the funicular polygon Fig. 10, locating their resultant which should have the same action line as P. The distance Z shows the error found.

Column Sections of Other Forms—A solid circular column may be handled in the same way as the hollow section just considered, the only difference being that the areas of some of the slices will be relatively larger because of the absence of the hole. Also the construction for sections of other shapes will be just the same except that the relative size and position of the different slices and rods will vary.

Application to Anchor Bolts and Column Bases—Figure 11 illustrates the base of a steel column which it will be assumed carries an axial load of 50,000 lb. in addition to a bending moment of 3,000,000 in. lb. This is equivalent to an eccentric load of 50,000 lb., having an eccentricity of 60 in. from the center of the columns. A plant of this base is shown to a larger scale in Fig. 12. The upper end in the figure being the compression end, and P the eccentric load of 50,000 lb. is located 60 in. above the center line of the column. Fig. 13 and Fig. 14 locate the neutral axis. Fig. 15 is now constructed in a way similar to that in which Fig. 4 was constructed and the resisting moment, when the maximum stress in the concrete is 400 lb. per sq. in., is found to be 1,985,000 in lb. Now the moment produced by the eccentric load P about the neutral axis is 43.4 times 50,000 equals 2,170,000 in. lb. This moment will produce a maximum stress in the concrete of 444 lb. per sq. in. The base line (ef) is moved to the left 50 lb. at a time, and the points (ehi), etc., located, through which is drawn the curve (eghiji). The intersection of the line (KL) (which is parallel to and distant from the (ae), P equals 50,000 lb.) with this curve gives K which locates the true base line (XY) from which the total maximum stress in the concrete (Xa) is found to be 165 + 144 = 609 lb. per sq. in. The stress in the anchor bolt is Yd × 15 = 15 × 1,260 = 18,900 lb. per square inch. If the stresses thus found are too high, they can easily be reduced. If the length of the base is kept constant while its width is varied, and if the area of the anchor bolts is varied directly as the width of the base, the unit stress in both anchor bolt and in the concrete will increase or decrease directly as the width of the base increases or decreases. Therefore, if the width of the base in the above problem is increased to 29¾ in., and 2⅜ in. anchor bolts are used, the stress in the concrete will be $609 \times \frac{20}{29.75} = 410$ lb. per square inch and the stress in the steel will be 12,700 lb. per square inch.



Figs. 11-19—Graphical Analysis of Stresses in Complex Column Sections

Check.—In an article on page 441 of vol. 70 of the Engineering Record, it is proved that some of the approximate methods for designing anchor bolts and base plates are more or less incorrect, and a correct method is given which involves a third degree equation. The results obtained by the graphical solution here presented have been closely checked by computations using the correct method just referred to.

A graphical check was made by Figs. 18 and 19.

The advantages of the graphical solution are (1) no complicated formulas need be developed or used and (2) it is much easier to see and understand just how the stresses really act and how they are distributed.

Supporting Wooden Flag Poles on Roofs.—One of the flag poles on a high building at Portland, Ore., recently broke off at the roof line and fell backwards upon the roof. An examination of the broken end of the flag pole showed that it was badly decayed at the roof line where it was surrounded by copper flashing. Yet it looked sound on the outside and only very careful inspection would have shown the danger. It had been in place about seven years. Commenting on this accident Mr. A. S. Lotspeich, Acting Inspector of Buildings for Portland, calls attention to the fact that many flag poles are supported by extending them through the roof to the framing several feet below, and are without braces or stays above the roof. Some are 40 or 50 ft. high. Rain water can usually run down the pole inside the flashing and decay is almost certain to start in a few years. The proper way to support them is by running a strong piece of steel beam or channel iron from the ceiling to a point 3 or 4 ft. above the roof, fastening the pole to this with iron straps, and if the pole is tall, guying or bracing it to the roof so that it cannot fall to the street even if it should break. The pole should not extend through the roof.

A $3,500,000 bond issue is contemplated by the city of San Francisco, Cal., for the erection of a school building. The project may be voted within the next three months.

In co-operation with the Bureau of Standards, the U. S. Forest Products Laboratory at Madison, Wis., is making a series of tests to determine the amount of current leakage through railway ties. This is said to be a very important factor to the railroad signal system and the Bureau is conducting similar tests in other localities as well. The work at Madison is being applied to a line of experimental track recently laid by the Chicago, Milwaukee & St. Paul R. R. in co-operation with the laboratory.

METHODS AND COST OF CONSTRUCTING A LOCK GUIDE WALL WITHOUT USE OF COFFERDAM.

The north guide wall at the Troy, N. Y., government lock was constructed without using a cofferdam by building the piers with precast, hollow rectangular reinforced concrete cribs set by a diver and filled with concrete poured under water. The plan, although somewhat restricted by having to use light units, the maximum weight of crib that would be handled by the available plant being only about 7 tons, worked out successfully and economically. The methods employed in the construction of the wall have been described by Mr. John P. McCabe, Junior Engineer, in the May-June issue of Professional Memoirs from which the notes that follow are taken.

The wall is made up of stepped piers, 21 ft. 9 in. long at the base, 10 ft. wide and placed 20 ft. center to center, with a top elevation of + 13.0 (mean sea level) carrying a continuous superstructure 12 ft. high with a section decreasing in width from 14 ft. at pier tops to 7 ft. at the coping.

The superstructure was to be built upon the filled cribs with the usual wall forms and the concrete placed by bucket. This would require the forms for the superstructure to be set in at least 2½ ft. of water, and as there would be a possibility of getting washed concrete at the faces when pool level would be above normal during the pouring, and also as the placing below water of the floor forms bridging the opening between the piers would very likely be slow and troublesome, it was decided to bridge the opening between piers up to elevation +16.3, or 2 ft. above normal pool level, with precast reinforced concrete girders for the faces, and with slabs for the floors, these being keyed into the concrete poured above the slabs. The superstructure was then continued with the usual forms, lapping the girders and extending to top of wall. Fig. 1 shows a section of the wall as made up of the cribs, girders and slabs, the number marked on each giving the order in which it was placed. Fig. 2 shows the details of a typical crib. A total of 78 cribs was required.

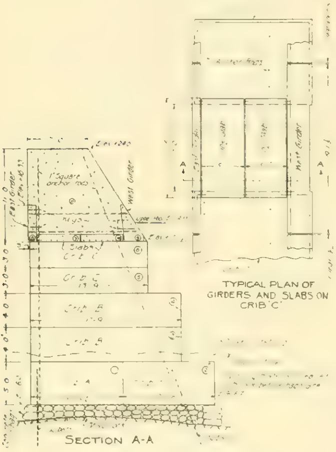


Fig. 1—Section of Guide Wall and Typical Plan of Girders and Slabs.

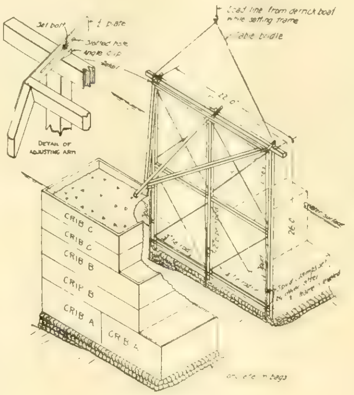


Fig. 2—Crib Setting Frame.

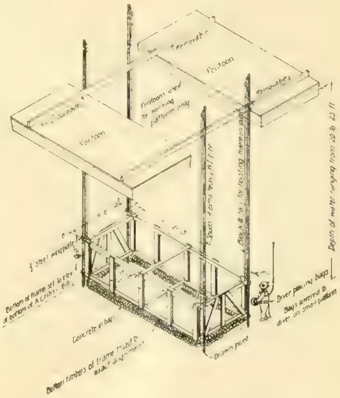


Fig. 3—Isometric View of Bag Setting Frame.

The cribs were designed to have a width equal to that of the piers, and to be strong enough to resist the pressure of concrete poured into them after having been cast 7 days, and yet light enough to be handled by the plant on the work. The latter point necessitated a small size of crib with very thin walls and with ample reinforcement, including diagonal and lateral cross rods running through each. These interior rods proved troublesome while filling the cribs with concrete, as they interfered with the placing of the tremie and very often fouled it when it was necessary to lower it quickly to prevent loss of the charge when the concrete would at times suddenly start moving from the mouth of the pipe.

The cribs, girders and slabs were built on the bank, about opposite the wall site, where a hydraulic dredge had discharged river sand and gravel while deepening the lock approaches. An analysis of this material showed it to be remarkably clean after having been discharged by the dredge (with about 3 per cent of silt and loam) and the sand and gravel suitably proportioned for concrete. Accordingly, this material was used for concrete without first separating, enough cement being added to give a mix of 1:2:4 proportion.

COST OF MAKING CRIBS, GIRDERS AND SLABS.

Labor—		
Form work (includes placing reinforcement)	$2,550.59	
Mixing and placing concrete (by hand)	1,190.38	
Handling cement	105.48	
Construction of plant and miscellaneous charges	330.12	
Total		$4,176.57
Material—		
Cement (at $0.85 net)	$ 413.10	
Reinforcement	583.89	
Material and supplies incidental to construction	314.05	
Miscellaneous	129.85	
Total		1,440.89
Total labor and material		$5,617.46
Total number of cubic yards		324
Cost per cubic yard		$17.34
Cost per linear foot of wall		$23.95

The concrete was mixed and placed by hand. The form work on the cribs progressed slowly, as the very narrow walls made properly enclosing the mesh and reinforcement difficult.

While casting the cribs, girders and slabs, a hydraulic dredge cleaned off the site of the wall and it was intended to start placing the cribs as soon as enough of them had aged 7 days. However, the urgent need elsewhere on the work of the derrick boat assigned to set the cribs, delayed the placing of the pre-cast parts until they had nearly all been completed,

Soundings taken after the dredge had been over the site of the wall showed the rock to be very irregular, with high spots not encountered in the early soundings and which were above the elevation determined upon as the base of the cribs, this elevation being such as to give a minimum volume of concrete to be placed in bags by the diver as a base for the cribs. A drill boat drilled and blasted these high rock spots, and the irregular pockets of material overlying the rock and not reached by the dredge were cleaned up by using the charging derrick and clam shell of the concrete boat, casting the material outside the limits of the wall.

COST OF BLASTING HIGH ROCK AND CLEANING OFF ROCK SURFACES.

Labor—		
Drilling and blasting	$ 43.65	
Cleanup with clamshell	459.53	
		$503.18

Material—		
Dynamite and miscellaneous	$42.71	
Coal	119.55	
		162.26
Total labor and material		$665.44

(Yardage not known, as material was cast outside of wall limits as excavated.)

After the rock had been prepared, the surface was leveled with concrete in bags placed by a diver on the lines of the crib walls and brought to the elevation of the bottom of the first tier of cribs.

Burlap bags were filled with concrete on the deck of a mixing boat placed alongside and moved along the site as the work progressed. This concrete boat was provided with a complete 1-yd. mixing outfit, with a derrick on one end for filling the sand and gravel bins and another on the opposite end for placing the concrete. As the bags were filled they were placed on a platform swung from the placing derrick and lowered to the diver. To guide the diver for both line and elevation when placing the bags, a setting device was used (Fig. 3) consisting of two rectangular frames set 5 ft. apart, braced together and hung on spuds of 4-in. extra heavy iron pipe by block and tackle operated from above the water. This frame conformed to the outline of the base of the piers and was set by lining the spuds from shore and lowering the frame on the spuds to the required elevation. After the frame was leveled, by reading on the four corners with a rod reaching above the water, the diver placed the bags of concrete, one bag wide, crosswise of the bottom timbers until the space between the bottom of the frame and the rock was filled. When the frame was removed four walls with level tops were ready to receive the first crib.

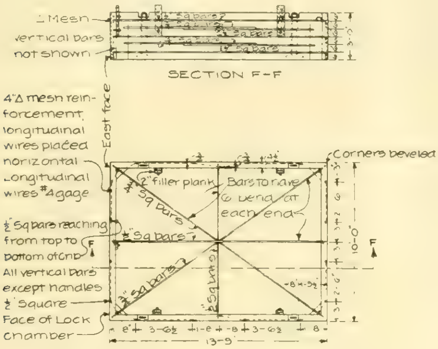


Fig. 4—Detail of Reinforced Concrete Crib.

COST OF PLACING CONCRETE UNDER WATER IN BAGS.

Labor—		
Mixing and placing concrete in bags	$2,443.39	
Handling cement	43.25	
Digging sand and gravel	28.62	
Miscellaneous	391.67	
		$2,906.93
Material—		
Cement (at $0.85 net)	$ 121.55	
Burlap bags	260.68	
Coal	101.54	
Material and supplies incidental to construction	37.37	
		521.14
Total labor and material		$3,428.07

Total cubic yards of concrete placed	1.43
Cost per cubic yard	$23.97
Number of bags placed	5,793
Cost of mixing concrete, filling one bag and placing	$0.59

To guide the diver in setting the cribs, a frame, as shown in Fig. 4, was used. This frame, provided with short spuds of solid 2-in. steel, was lined and plumbed from above water. The faces of the frame timbers were carefully dressed to a plane surface, well braced together to prevent warping and kept always in water to prevent drawing by the sun.

When the bottom cribs had been set on the prepared foundations, a drill boat drilled the holes for the anchor rods. The diver spotted the drill by using the walls of the cribs for a guide, telephoning instructions for shifting the drill boat as desired. Care was taken in shifting and placing the drill not to foul the interior rods of the cribs, and thus displace the cribs. As each hole was drilled and cleaned the anchor rod was dropped in and grouted from the deck of the drill boat, using a casing reaching well above water.

After the anchors had been placed the upper cribs were set and the long vertical reinforcing rods worked down between the crossrods of the cribs, clipped to the anchors and held in place at the surface of the water with a wooden template guyed to the handles of the top crib.

It being near the close of the season for river work when the bottom cribs were set, it was realized the wall could not be completed to top of cribs, so the bottom cribs only were placed and filled the first season, excepting those of the continuous 40-ft. section at the north end which were placed to the top and filled.

This necessitated the diver clipping short rods to the anchors in all cribs but those of the north end to provide for lap of the long rods to be placed the following season. This nearly doubled the cost of placing the reinforcement.

COST OF PLACING ANCHOR RODS AND REINFORCEMENT.

Labor—		
Drilling	$ 203.59	
Placing anchors and reinforcement and grouting	1,051.82	
Miscellaneous	55.86	
		$1,311.27
Material—		
Cement	$ 30.00	
Rods	234.50	
Coal	20.00	
		284.50
Total labor and material		$1,595.77

Total number of pounds of rods	21,154
Cost per pound	$0.075
130 5-foot holes drilled, feet	650
Cost per foot drilling	$0.313

When the reinforcing rods were in position the cribs were filled with concrete poured through a tremie.

When first used the tremie was hung between two pontoons from a heavy frame carrying the hopper into which the concrete was discharged, and operated by block and tackle leading to a hand winch on the pontoons. Three different lengths of pipe were used, the longest about 22 ft., shorter sections replacing the longer as the concrete was brought up. This rig was cumbersome, slow and difficult of operation and very often allowed the charge of concrete in the pipe to get away before the pipe could be lowered quickly enough to check the flow. Washed concrete resulted in spots and had to be removed later by the diver.

Nearly half of the concrete in the cribs was poured with this rig, but as soon as a derrick boat was available only the longest length of pipe was used by hanging it directly from the hopper, which was surrounded by a working platform, the whole swung from the derrick boom. The pipe, filled with concrete, was easily and quickly raised or lowered by the derrick with no time lost for changing pipe lengths, and resulted in saving fully 50 per cent of time as well as giving more satisfactory concrete.

COST OF PLACING CONCRETE UNDER WATER WITH TREMIE.

Labor—		
Mixing and placing concrete	$2,538.34	
Handling cement	354.63	
Digging sand and gravel	391.30	
Miscellaneous	229.27	
		$3,513.54
Material—		
Cement (at $0.85 and $1.25 net)	$1,576.40	
Coal	86.42	
Supplies and material incidental to construction	61.93	
		1,724.75
Total labor and material		$5,238.29

Total cubic yards placed	1,148
Cost per cubic yard	[illegible]

The concrete for filling the cribs was a 1:3:6 mix with enough water to make a mushy mass, but not wet enough to cause water to collect at the top while standing in the hopper. To prevent the initial charge from dropping through the water, a gunny sack was stuffed with straw and rammed into the top of the pipe. The concrete was then lowered on to it, forcing it down slowly. When the sack reached the bottom it freed itself automatically and floated to the surface. This method proved quite satisfactory.

The first concrete poured through the pipe was made about as stiff as that placed in open forms, but it would not only fail to flow away from the pipe into the surrounding area of the cribs, but on two occasions arched and stuck in the upper part of the pipe, while the lower mass dropped to the bottom with the resulting vacuum which collapsed the pipe as flat as if it had been through a train of rolls. The matter of the consistency of the mix greatly affected the speed of placing the concrete, the fairly soft mix being easier to get through the pipe quickly and continuously, moving more evenly away from the end of the pipe and not washing like the drier mix, as it seemed to stick in a mass better under water and resisted percolation by the agitated water beyond the outer film of mortar. Because of the mass of crossrods in the crib the pipe had to be set each time by the diver, as it was impossible to work it down through the interior rods from above without great loss of time. This required the services of the diver at times during the pouring of concrete, at the limited volume allowed for continuous pouring necessitated frequent shifting of the tremie from one pier to another.

When the cribs were filled, a derrick boat set the girders and slabs. The 3-in. overhang of the superstructure may be noted, shown in Fig. 1. This was adopted so that if there were slight irregularities in setting the cribs (as was unavoidable) there would be no part projecting beyond the face of the superstructure. The girders were lined by a transit from the lock wall and held in position by two rows of short rods placed in holes provided in the girders and joined by long rods between with a sleeve joint just inside the girders, allowing the short rods through the girders to be removed after the concrete had set. On top of these rods were placed 4x4-in. struts cut to correct distance between inside of girders, and removed as the concrete was brought up to them.

COST OF TRANSFERRING AND SETTING CRIBS, GIRDERS AND SLABS.

Labor—		
Diving and derrick boat crews and laborers	$3,547.65	
Construction of plant, repairs and miscellaneous	611.09	
		$4,158.74
Material—		
Coal	$ 253.77	
Supplies and material incidental to construction	85.54	
		339.31
Total labor and material		$4,498.05
Total linear feet of wall		235
Cost of setting, per linear foot		$19.14

Concrete was next poured between the girders to their tops and the forms for the remainder of the superstructure set on timbers bolted to the girders a little below the top, using the short rods through the girders mentioned above. No difficulty was met with in placing the upper forms, except that work on the outside of the forms had to be done from floats.

COST OF SUPERSTRUCTURE.

Labor—		
Form work	$1,315.04	
Setting iron and steel	94.87	
Mixing and placing concrete	439.18	
Handling cement	182.85	
Digging sand and gravel	65.48	
Miscellaneous	296.41	
		$2,393.83
Material—		
Cement	$1,141.25	
Cast iron and steel	378.30	
Coal	103.86	
Supplies and material incidental to construction	92.18	
		1,715.59
Total labor and material		$4,109.42
Total cubic yards placed		913
Cost per cubic yard		$4.50

The work was carried on during the navigation period with boats constantly entering and leaving the lock and was repeatedly interrupted by tows hitting the setting frames, on two occasions damaging them so that they had to be sent to the bank for repairs. After the north end section had been brought to the water surface, the work was guarded by a cable stretched from the cribs at that end to the river wall, on the lock side, with heavy timbers stapled to it and floating on the surface of the water. These fenders could not be placed much beyond the face of the wall because of obstructing the lock approach and there was enough spring in the cable to allow a boat bumping the timbers to hit the uncompleted work. Several of the top cribs had to be reset and there was continual trouble with the girders being struck before the concrete had been poured their height.

The diving crew consisted of two divers, each doing a four-hour trick below the water while the other directed operations above, with two men on the pump, one man tending to telephone connected with the diver's helmet and one man tending the life and telephone lines and air hose. This crew was provided with a small scow about 11x25 ft., with a shelter on deck for storing the pump and equipment and for drying out the diving dresses when not in use. A ladder, swung from the side of the scow, allowed the diver to descend below the water surface before swinging from the life line to be led by the attendant to the desired spot. The divers were employes of the Engineer Department already connected with the work at Troy as foremen, experienced in diving work, and who proved exceptionally reliable and efficient. The derrick boat crew for handling the cribs, girders and slabs consisted of the engineman, fireman, and four laborers who handled the tag line from the cribs, etc., when being set, swinging the pieces as directed by the diver through the telephone. These two crews with the watchmen, were employed continuously on the guide wall work. When concrete was being placed, another derrick boat, with an engineman and fireman for handling the tremie when in use, and the concrete crew, consisting of foreman and nine men, were used in addition.

SUMMARY OF COSTS.

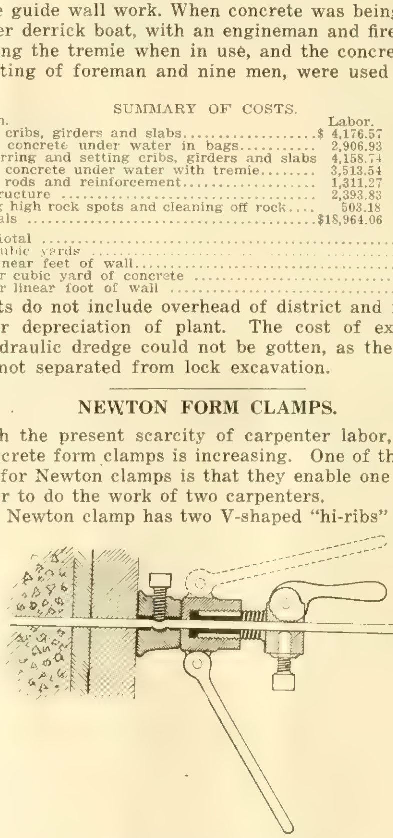
Item.	Labor.	Material.
Making cribs, girders and slabs	$ 4,176.57	$1,440.89
Placing concrete under water in bags	2,906.93	521.14
Transferring and setting cribs, girders and slabs	4,158.74	339.31
Placing concrete under water with tremie	3,513.54	1,724.75
Anchor rods and reinforcement	1,311.27	284.50
Superstructure	2,393.83	1,715.59
Blasting high rock spots and cleaning off rock	503.18	162.26
Totals	$18,964.06	$6,188.44
Grand total		$25,152.50
Total cubic yards		2,828
Total linear feet of wall		235
Cost per cubic yard of concrete		$8.89
Cost per linear foot of wall		$107.04

Costs do not include overhead of district and field offices, or depreciation of plant. The cost of excavation by hydraulic dredge could not be gotten, as the charges were not separated from lock excavation.

NEWTON FORM CLAMPS.

With the present scarcity of carpenter labor, the use of concrete form clamps is increasing. One of the claims made for Newton clamps is that they enable one common laborer to do the work of two carpenters.

The Newton clamp has two V-shaped "hi-ribs" opposite the end of the set-screw and the bottom of the hole is concaved in such a manner that when the set-screw is tightened down on the rod or wire, it clamps, making it impossible for the clamp to slip.



Newton Clamp and Method of Operation.

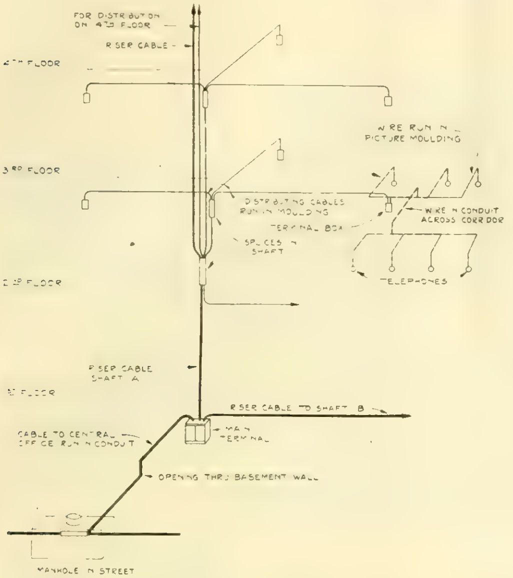
The illustration shows the manner in which the concave bottom and V-sloped shoulders hold the rod or wire. It also shows the details of the Newton Improved Tightener, which has a cam; can be attached readily to the rod or wire and quickly released. These devices are manufactured by the Newton Mfg. Co., 812 Walnut St., Kansas City, Mo.

PROVIDING FOR TELEPHONE SERVICE REQUIREMENTS IN DESIGN OF LARGE BUILDINGS.

The telephone is such an important factor in modern existence that adequate provision should be made for service appliances in the design of a building.

In modern office buildings, hotels and apartment houses, large numbers of telephones are required. It would be impracticable and inconvenient to install a pair of wires through one of these buildings, each time a telephone is installed, in order to establish connection with the outside wire of the telephone system.

When the building plans are prepared, a forecast should be made of the future requirements of the building as a whole and facilities should be provided for an adequate amount of cabling, with the necessary cable terminals, and the subsidiary wiring.


FOR DISTRIBUTION ON 4TH FLOOR
RISER CABLE
4TH FLOOR
WIRE RUN IN PICTURE MOULDING
3RD FLOOR
DISTRIBUTING CABLES RUN IN MOULDING
WIRE IN CONDUIT ACROSS CORRIDOR
TERMINAL BOX
SPLICES IN SHAFT
TELEPHONES
2ND FLOOR
RISER CABLE SHAFT A
1ST FLOOR
RISER CABLE TO SHAFT B
CABLE TO CENTRAL OFFICE RUN IN CONDUIT
MAIN TERMINAL
OPENING THRU BASEMENT WALL
MANHOLE IN STREET

OFFICE BUILDING

SKELETON CABLE AND WIRING DIAGRAM

Skeleton Cable and Wiring Diagram for Office Building.

All large cities contain many buildings that are cabled and wired for telephone service according to a comprehensive plan, and of the smaller places there are but few that do not have some buildings of a character requiring more or less provision of this kind.

Every large building, to a certain extent, presents problems peculiar to itself and advantageous and economical arrangements can frequently be suggested by those familiar with work of this kind.

For an explanation of some of the more prominent features of comprehensive wiring, buildings can be divided into the following classes:

Office Buildings.
Loft and Manufacturing Buildings.
Hotels.
Apartment Buildings.

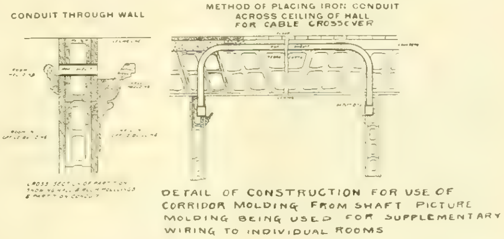
In one respect office buildings and loft and manufacturing buildings are distinct from the other two kinds. In office or loft and manufacturing buildings, adjustments are continually being made to suit the requirements of a changing tenancy. Private branch exchanges are required at certain locations for longer or shorter periods, and it must be possible to distribute from these private branch exchanges to the private branch exchange telephones on the same floor or on other floors. Partitions are changed or removed and corridors are lengthened or shortened to suit the needs of tenants.

The office building requires a permanent cable system with distributing branches, which end in cable terminals at which connection is made between the individual distributing circuit and the main cable. This permanent backbone of cable extends vertically upward from the basement to the points at which it distributes horizontally on the several floors.

In the basement this cable is connected to a main terminal consisting of a rack affording facilities for making cross-connections as required between pairs in the house cable and pairs in the main feeder cable extending to the central office. It is also frequently necessary to make connections between certain pairs in the building riser cable and other pairs in the same cable extending to other floors. If the building covers a considerable area and there is more than one riser cable, all of the riser cables will be brought to this master terminal.

These master terminal racks, in the case of large buildings, necessarily occupy considerable space. As this appliance is a most important factor in the telephone service, it should be placed in a clean, dry and accessible location where it will not be subject to interference.

From the riser cables, branch cables of proper size are extended to distributing cable terminals. The locations of these terminal centers should be chosen so as to admit of the shortest practicable wire runs to the offices. This will keep down the quantity of distributing wire and make unnecessary any clumsy effort at concealment.


CONDUIT THROUGH WALL
METHOD OF PLACING IRON CONDUIT ACROSS CEILING OF HALL FOR CABLE CROSSOVER
DETAIL OF CONSTRUCTION FOR USE OF CORRIDOR MOLDING FROM SHAFT PICTURE MOLDING BEING USED FOR SUPPLEMENTARY WIRING TO INDIVIDUAL ROOMS

Detail of Construction for Use of Corridor Molding for Shaft. Picture Molding Is Used for Supplementary Wiring in Individual Rooms.

Provision should be made for this cable, either with iron conduit or with a combination of iron conduit and corridor or picture moulding.

In the general type of large office buildings the riser cables are placed in a vertical riser shaft where they are accessible on the different floors. From this wire shaft on each floor a conduit is run to a number of points at the corridor mouldings and at these points cable terminals are located and the distribution made with individual circuits.

In some cases additional cables are extended along the corridor mouldings. This is more particularly the case when it is desired to connect a private branch exchange with the corridor terminal. From the corridor moulding to the picture moulding, on the opposite side of the partition, a conduit bushing is placed, generally on either side of each column. This removes the necessity of boring through the partition to get from one side to the other.

In buildings over eight stories in height it is preferable to place the riser cables in suitable wire shafts rather than in conduits, as the advantages of conduit are offset by the difficulty of installing and properly supporting the large cables in the conduits and making the large and complicated splices in the outlet boxes that are a part of the conduit system. For buildings of less height, where the riser cables are very large, the conduits should not be used, for the same reasons. The service requirements for office buildings vary considerably. There have been cases where, for certain parts of a building, a pair has been required for every 100 sq. ft.

The distinctions between an office building and a loft or manufacturing building in the design of the wiring are that for the latter less facilities will be required, greater changes take place in the distribution with changes in tenancy, there are not so many partitions and the matter of concealing the wire and cable is not of such importance. It is generally better, in such a building, to keep the cable terminals close to the wire shaft or elevators so that moves of the terminal and its connecting cable will not be required with partition changes. The forecast for such a building would depend upon the character of its probable tenancy, but there are buildings of this character that have a development as high as one pair to 800 sq. ft.

The telephone systems for hotels and apartment buildings differ from those just described in one important respect. These buildings can be wired in advance on a permanent basis on account of there being little probability of a change in the number of wires needed, the ultimate requirements being closely determined by the number of rooms or apartments.

The location of the individual telephone instruments is generally permanent and the arrangement on one floor is similar to that on other floors.

For a hotel, a private branch exchange switchboard, located in or near the office of the building, generally handles the major portion of the telephone service, this switchboard being connected by the proper number of trunk lines with the nearest central office of the telephone company. From this switchboard sufficient cable should be provided to get a margin above one pair to each room, this margin to take care of a few direct lines required by permanent guests and by the possible needs suggested by the availability of the hotel for convention patronage.

In hotels, conduit is more generally used for distributing wires on floors than in other buildings, because the location of the telephone is more permanent, the closets and bathrooms interfere with the moulding method, and occasionally guests sleep during the day and do not like to have people not connected with the hotel service working in the corridors.

Conduits for distributing wires on floors in hotels should not be over 50 ft. in length nor should they have more than three bends with a minimum radius of 5 in. Any conduit 100 ft. in length should not be less than 1 in. in diameter; ½-in. conduit should be provided for a maximum of 2 pair of wires, and ¾-in. conduit should be provided for a maximum of 4 pair of wires.

If more than 20 pairs of wires are required on each floor it is generally desirable to have more than one wire shaft.

For apartment buildings the general need is for circuits connected directly with the central office.

The outside service, though in some cases underground, is generally overhead and entrance is made through the basement. The wiring or cabling can be done without concealment in the basement, but it is desirable to have at each vertical tier of apartments a vertical conduit extending up from the basement. This often appears in a closet of each apartment, the wiring from this point being extended to the instrument on picture moulding. This is a very inexpensive method and entirely removes the necessity of disturbing any tenant, except the one whose telephone is involved, for installations or repairs.

There are continual changes in building methods and problems arise which require special treatment. It is to the advantage of building owners to have these matters properly cared for and the telephone companies desire to co-operate with architects when a building is being designed. The telephone company's experts will be glad to consult and afford any information that is needed to plan the work in the best way.

Plans have been completed in the last few days for the erection of two large hotel buildings. One of these will be built at Cleveland, O., at a cost of about $4,000,000; the other is proposed for Detroit, Mich., and will cost about $3,000,000.

JAPANESE MASONRY WORK.

Contributed by J. L. Harrison.

To an American engineer accustomed to the use of concrete for all forms of permanent heavy construction, a trip through Japan will reveal nothing of more interest than Japanese masonry work. This masonry work is encountered on every hand and seems to enter into Japanese heavy construction as completely as concrete work enters into American heavy construction. In fact every mental impression of this wonderful country has in it somewhere a wall or a quay on a bridge built in the peculiar Japanese fashion.

Japanese masonry seems to be an evolution. Some of the oldest walls are made of large blocks of rough stone chinked up with smaller stones and one occasionally sees a retaining wall, apparently of great age, which has been constructed of large boulders carefully set together, the obvious impression being that when these walls were built the Japanese lacked adequate means of breaking and cutting stone. But all of the recent work seems to have been more standardized and is made of blocks which usually present face from 15 to 18 in. square.

These stones are not usually dressed to accurate dimensions, and often vary a good deal from being perfectly square, so the courses are neither level nor regular. However each stone as it is laid is cut to fit the stones below it and the stone just previously laid, so the courses are kept fairly regular; but little effort seems to be made to break joints and walls are often seen where the method of laying the stone necessarily results in there being no broken joints. Moreover, the courses of stretchers are absent.

In spite of these peculiarities no morter is used in most of the work. The stones are accurately fitted and a good bearing between stones secured. One would expect to find a good many broken stones as a result of poor bearing between stones or of unequal strain, but as a matter of fact broken stones, even in high walls, are rare and the writer has never chanced to find a wall that seemed to be in distress due either to overload or to poor foundations.

This peculiar cut stone masonry without mortar is used for all forms of retaining walls, for river walls and for sea walls, and is seen in bridge piers and abutments and while one sometimes sees structures where mortar has been used, they are not common.

The size of some of the structures undertaken is considerable. The writer measured one retaining wall in Nagasaki which is approximately 40 ft. high, and this was not the highest one which he saw. Lower walls of the same type are one of the commonest sights in Japan. One also sees miles of river wall and harbor quays built in this fashion and wonders how they endure, but he never sees a stone out of place or the slightest indication of distress.

There does not seem to be any standard slope for these walls, nor does there seem to be any standard of thickness. The first wall which the writer saw built was practically a masonry facing for a newly made street cut. It was about 2 ft. thick, some 20 ft. high at the highest point, about 100 ft. long, had a rise of about 2 ft. to each foot of run, and a practically uniform slope.

On the other hand, a harbor quay recently seen under construction in Nagasaki was much nearer vertical, and seemed to have a thickness almost equal to its height. Its total height could not be determined as the bottom of the wall was under water and no one on the job talked English. The stones used in this wall were roughly twice as long as they were thick, but there did not seem to be any special effort to bind the courses of stone together even on the interior of the wall.

Still another wall, observed under construction some years ago, had a thickness of about half of its height. The natural conclusion is that there is no very definite standard as to the rates of thickness to height, but that the thickness is varied according to the nature of the work and, no doubt, also according to the prejudice of the man in charge of the work.

There is no more regularity in regard to the slope given to the face of these walls than there is as to the ratio of the thickness to the height. Within a distance of a hundred yards of each other the writer found three retaining walls. The first had a rise of about 20 ft. in a run of about 15 ft. The slope of the face of this wall was uniform. Next to it was a wall some 15 ft. higher, but this height was attained in a run of only about 10 ft., and instead of a uniform slope the face was slightly curved. The last of the three walls was nearly 40 ft. high, with a run of about 20 ft. The base courses of this wall were laid with a rise of considerably less than a foot to a foot of run, the ratio rapidly changing toward the top, which for the last 10 ft. was practically vertical. This produced a face curved on the lines of a sort of rakish parabola, an effect seemingly very popular among the Japanese.

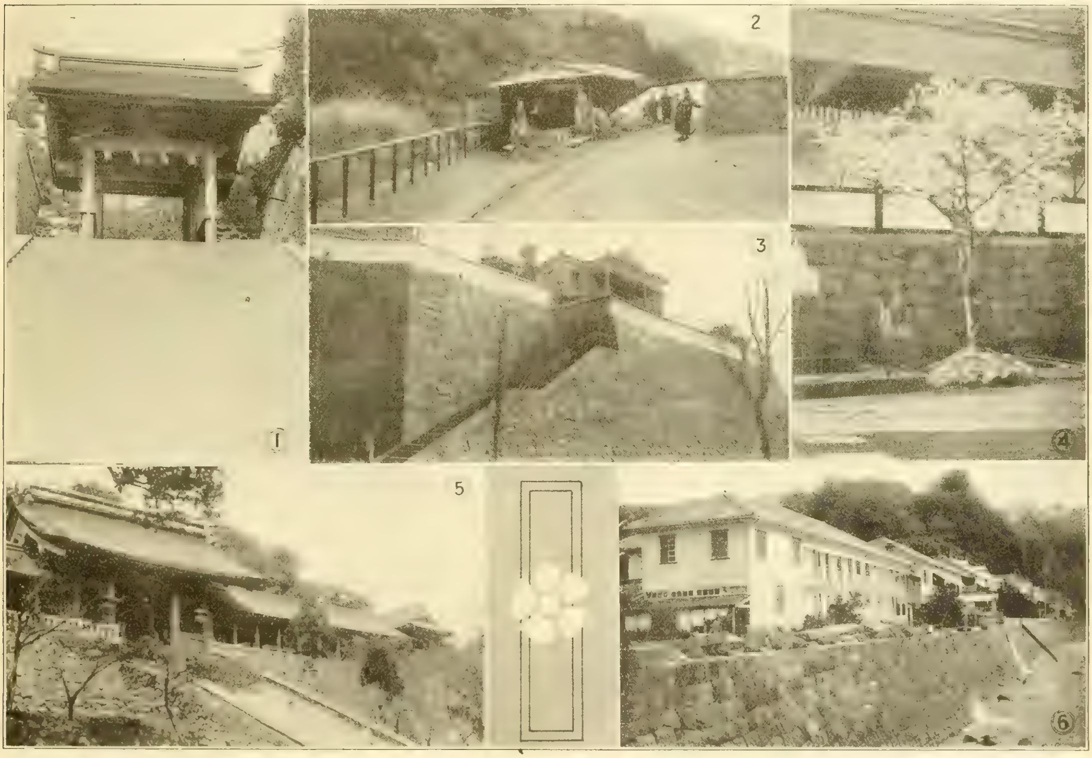


Fig. 1—Fine Flight of Steps Laid Without an Ounce of Mortar. Fig. 2—At the Right a Well Laid Recently Built Japanese Retaining Wall. The Arrangement of the Stones Would Not Impress an American Engineer as Proper. Note That in Many Instances the Joints Are Not Broken. Fig. 3—A Typical Street Retaining Wall. This Wall Is Over 30 ft. High and Has Been Made Necessary by the Excavation of the Street to a Grade Low Enough to Accommodate Japanese Street Traffic. The Lots Are Not Excavated, the Houses Being Reached by Long Flights of Steps. Fig. 4—A Very Old Wall Before the Act of Breaking Stone Was as Well Understood as It Is Now, It Was Easier to Build Walls Out of Boulders and Large Blocks of Stone Than to Break Up the Stone into Convenient Sizes. Fig. 5—An Old Wall. Trimming the Stones to a Fairly Accurate Fit Is a Modern Development. In the Older Walls No Effort Was Made to Do This as Stone Cutting Took an Enormous Amount of Time. Fig. 6—A Sea Wall Near Nagasaki.

In fact these curved faces seem to be the Japanese preference, but even at that there seems to be no definite standard for the amount of curvature given to the slope of the face of the walls built, and variations as marked as the ones here noted are common.

These walls seem the more remarkable when one notes that the stone used is a very hard igneous rock, showing many quartz crystals in a dark amorphic ground mass. Such a stone is extremely hard to cut with ordinary mason's tools. However, once in place, a structure built of such a material is permanent, but to build it requires an enormous amount of fairly intelligent cheap labor. Of course Japan provides no end of cheap labor which is undoubtedly the most intelligent cheap labor in the world. But even at that, one cannot but wonder whether more modern forms of construction would not be advantageous even in Japan. In fact, there is evidence that the Japanese take this same view of the matter, for in spite of the fact that these masonry walls are still a standard form of construction, one sees a steadily increasing percentage of concrete work and it may be that even in Japan the day of extensive rough masonry work is about over.

SIZE OF MIXER AND SIZE OF JOB ON WHICH MIXER SHOULD BE USED.

Some interesting information on railway practice in the handling of concrete are given in a committee report presented at the last annual convention of the American Railway Bridge and Builders' Association. In order to secure data as a basis for the report the committee sent out a list of questions to various railways. Replies were received from 41 different lines, representing a total of 127,500 miles. Information was requested as to the size of mixers considered most desirable for small work and as to the minimum size job on which a mixer was justified. The size of mixer recommended showed considerable variation, evidently, larger work being considered in some instances in the replies. Only 6 prefer hand mixing for small work. Sixteen recommend mixers with from 6 to 9 cu. ft. capacity unmixed charge. This corresponds to a 1-sack batch mixer. Eight prefer a ½-yd. or 2-sack batch mixer and two use ¾ yd. machines. The opinions as to the minimum sized job on which the use of a mixer is justifiable varied widely. Four roads recommend using some form of mixer for quantities as small as 5 yd. Six would use one where the quantities are from not less than 10 to 30 yd., five set 50 yd. as the limit and six consider 100 yd. a minimum.

DISTRIBUTION OF PRESSURE IN EARTH DUE TO CONCENTRATED EXTERNAL LOAD.

Very little experimental data are available on the distribution of vertical pressures transmitted from an externally applied load through various depths of soil. Tests to determine the matter were made some years ago at the engineering department station of the Pennsylvania State College in co-operation with the Pennsylvania State Highway Department. These tests have continued and are described in a recently issued bulletin prepared by Mr. R. B. Fehr, from which the matter following has been taken:

The subject of earth pressure is difficult to approach from an experimental standpoint largely because of the extreme variation in the mechanical composition and properties of different soils, especially with regard to the action of cohesion and internal friction in the material. Dry sand was used in the first experiments for the reason that it is more homogeneous, more uniform in its properties and, therefore, more likely to give concordant results. Furthermore, as sand gives the minimum arching effect, the loads transmitted will represent the maximum or worst possible condition of loading, and consequently data obtained for sand will be on the safe side for all other soils. After obtaining sufficient data on sand it was the intention to investigate similarly other soils such as gravel, loam and clay.

The present series of tests had the following special objects in view:

1. To check the results for sand as found in the previous tests.
2. To obtain data on soils having considerable cohesion.

Description of Apparatus.—The apparatus was designed and constructed for the purpose of applying loads up to 6 tons. It consists of a box 12 ft. by 6 ft. supported on concrete piers by means of I-beams and joists. In the center of the floor of this box is cut a hole 12¼x 12¼ in. in which is placed the "weighing strip" supported by the platform of a 4,000 lb. "Standard" scale through a wooden column 36 in. by 10 in. by 6 in. Surrounding the weighing strip is a "restricting" box for containing the soil under test. In the check tests on sand the box was 4 ft. 6 in. wide by 9 ft. 4 in. long by 5 ft. deep. The loads are applied by means of a calibrated hydraulic jack on a wooden loading strip 12 in. by 12 in. by 3½ in. resting on the surface of the soil. The jack is blocked up so that it works against the overhead I-beam. The end tension rods are threaded so as to permit easy adjustment of the height of the beam above the surface of the soil.

The platform scale has a lever ratio of 200 to 1, and since the play of the beam was restricted to ⅛ in., the maximum movement of the platform was only ⅛ × 1-200 = 1 = 1600 in. The errors resulting from a rearrangement of the soil due to an excessive movement of the weighing strip were consequently reduced to a minimum.

The hydraulic jack, although having a capacity of 20 tons, is only 10 inches in height and 4 inches in diameter. With an independent pump, and calibrated gage it made a very convenient means of applying a known load. A good grade of gas engine cylinder oil was employed as the working medium.

Method of Conducting Tests.—In conducting these tests a uniform method of procedure was adopted. A piece of canvas was spread lightly over the weighing strip to prevent the soil from running through the ⅛-in. spaces between the weighing strip and the box. The soil was then shoveled in and leveled off at a certain depth. The loading strip was firmly imbedded by hand pressure so as to have a good bearing area. The jack was then placed in position and blocked up against the I-beam. A dead-load reading of the platform scale was taken and loads were applied and readings of the scale beam noted for various loads as indicated by the gage up to the capacity of the apparatus, or to a point when the loading block sank into the soil as fast as the load was applied. The difference between the two scale readings, namely, before and after applying the load, gave the amount of pressure transmitted through the soil. One hundred times this difference divided by the known weight of the load as determined from the calibration curve gave the percentage of the load transmitted vertically through the soil. The distribution of this transmitted pressure was readily determined by the varying position of the loading strip. Great care was exercised in preventing the jack from getting out of plumb so as to make sure that the loading strip would sink evenly into the soil. Whenever uneven sinking occurred the test was discontinued and run over again. Throughout all the tests the method of applying the load was precisely the same as that employed in calibrating the jack and gage.

Sand Tests.—A series of tests was run on dry sand for the purpose of determining the effect of the size of the "restricting box." The size of the box used for this purpose in the previous tests was 3 ft. by 4 ft. deep. In the present series the size was increased to 4 ft. 6 in. by 9 ft. 4 in. by 5 ft. deep. Suitable bracing was provided in order to prevent the sides of the box from bulging when large pressures were used.

The sand used in these experiments was the same as that used in the former experiments, namely, clean, dry river sand, of medium sharpness—a typical brown building sand.

The following depths of sand were tested: 3, 6, 12, 18, 24, 36, 48 and 59 in. For each depth the eccentricity of the load was varied from 0 to 42 in. both right and left. The loads were applied in increments of 1,000 lb. as indicated by the gage up to the point where the loading strip sank into the sand as fast as the load was applied. As determined from the calibration curve these loads varied from about 600 lb. to between 2,200 and 6,000 lb. according to the depth of the sand.

Discussion of the Results on Sand.—The curves in Fig. 1 show the distribution of the vertical component of pressure due to a concentrated external load. The points plotted are the averages of all the results obtained for a given depth of sand and a given eccentricity of load. On the average about eight observations are represented by each of these points. The calculated percentages of transmission lie for the most part well within 10 per cent of the mean value, as in the previous tests. It will be noted that there was a very marked change in the per cent of transmission when the eccentricity of the load was equal to the width of the weighing strip, and at this point the maximum value was 13 per cent. For greater eccentricities this value was never exceeded.

The two curves in Fig. 2 show how the results of the present series of tests compare with those of the previous series. These curves practically coincide, and therefore indicate that the size of the restricting box does not make any appreciable difference in the results.

The maximum bearing power of the sand decreased with the depth of sand as shown in Fig. 3, the plotted points in the curve being the averages of the maximum loads that could be applied at 0 eccentricity. The cause of this was possibly the fact that the sand has more opportunity to flow at the greater depths.

Furthermore there was a distinct tendency for the percentage of transmission to increase as greater loads were applied. The point is well illustrated in Fig. 4. Curve A shows the maximum values for sand obtained by averaging the results for the two highest loads that were applied. These loads averaged from 3,000 to 5,000 lb. Curve B shows the results obtained in the previous tests under the same conditions, but with loads up to 300 lb. only.

Tests on a Clay Mixture.—It seemed desirable to investigate a soil having a high degree of tenacity as opposed to sand, which has practically no tenacity. Accordingly various mixtures of clay, loam and sand were tested for tenacity in the soils laboratory of the School of Agriculture. The mixture, which appeared to give maximum tenacity and which was therefore used con-

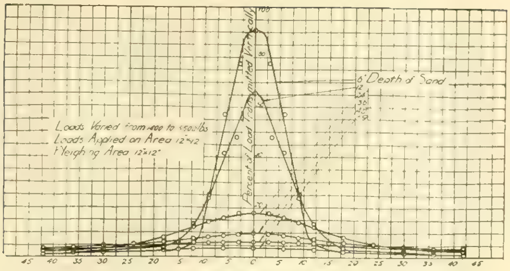


Fig. 1

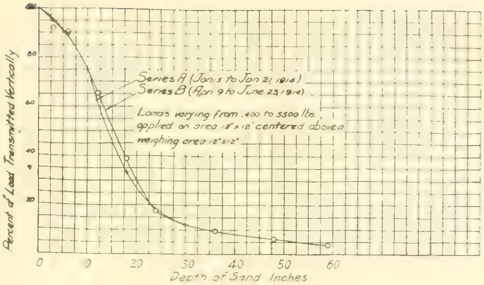


Fig 2

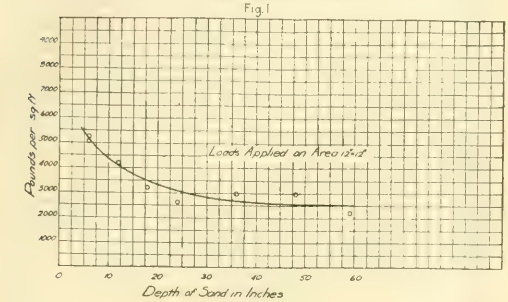


Fig 3

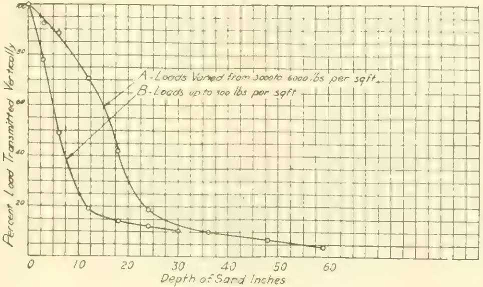


Fig 4

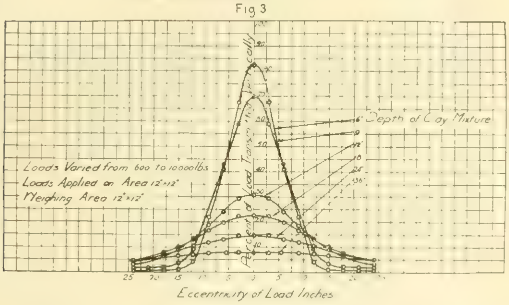


Fig 5

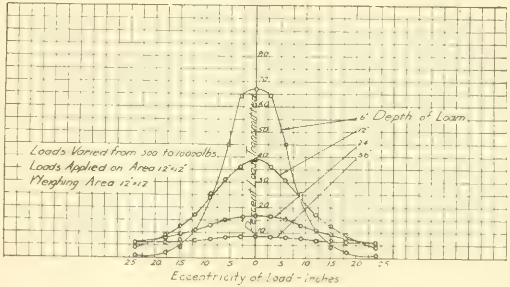


Fig 6

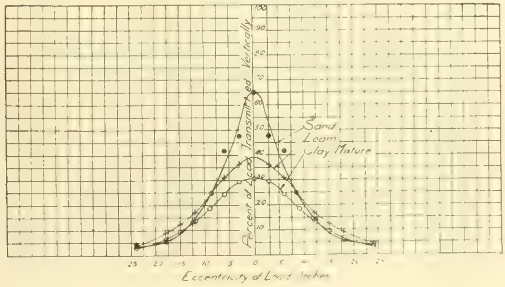


Fig 7

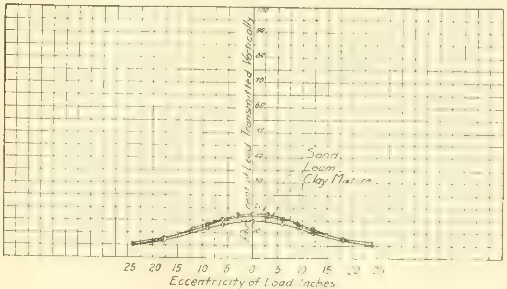


Fig. 8

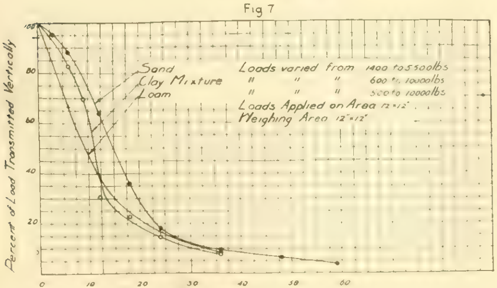


Fig 9

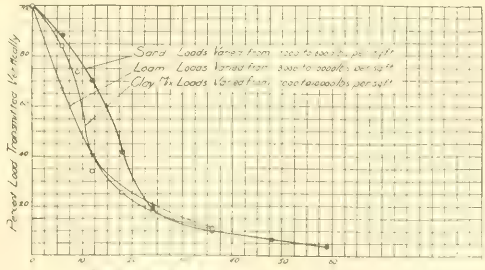


Fig 10

Fig. 1—Curves Showing Per Cent of Load Transmitted at Various Distances from Center for Different Depths of Sand. Fig. 2—Showing Comparison of Results from Two Series of Tests on Sand. Fig. 3—Curve Showing Relation Between Maximum Bearing Power of Sand and Depth of Sand. Fig. 4—Curves Showing Comparison of Per Cent Transmission in Sand for High and Low Pressures. Fig. 5—Curves Showing Per Cent of Load Transmitted at Various Distances from Center for Different Depths of Clay Mixture. Fig. 6—Curves Showing Per Cent of Load Transmitted at Various Distances from the Center for Different Depths of Loam. Fig. 7—Curves Showing Comparison of Results for 12-Inch Depths of Various Soils. Fig. 8—Curves Showing Comparison of Results for 24-Inch Depths of Various Soils. Fig. 9—Curves Showing Comparison of Results for Three Kinds of Soil. Fig. 10—Curves Showing Maximum Percentages of Transmission.

sisted of 85 per cent clay, 10 per cent sand and 5 per cent loam. Technically the soils may be described as follows:

1. Silty yellow clay (containing practically no gravel).
2. Gravelly phase of a silty loam (containing 22 per cent gravel).
3. Brown River sand (the same as in previous tests).

The above material was run through a screen of approximately ¼-in. mesh, and spread out on the floor. After being thus room-dried for 24 hours the 85-10-5 per cent dry mixture was made up as required. The mixing was done by hand with concrete shovels until a uniform color was obtained. When ready for testing the mixture had just enough moisture to cohere slightly when compressed by hand. Some idea of its tenacity may be gained from the fact that when the heavy loads were applied a brick was formed that could be broken up only by means of a pick. The following are the chief physical characteristics of this mixture.

Moisture	11.3 per cent
Weight per cu. ft., loose	83.0 lb.
Weight per cu. ft., packed	103.5 lb.
Angle of repose	38.5 degrees

Meanwhile a new test box for containing the soil under test had been constructed. As the two series of tests on sand indicated that the size of this box did not make any noticeable difference, the new box was made as small as possible, but large enough to obtain the distribution of pressure. It was 6 ft. long by 2 ft. wide by 5 ft. high and was built in two sections 2 and 3 ft. high for the sake of convenience. The lower section of the box was placed centrally on the floor of the test apparatus and securely fastened.

The mixture was shoveled into the box and leveled off at a depth of 6 in. The method of procedure was exactly the same as in the sand tests except that the eccentricty of the load was varied from 24 in. right to 24 in. left, and back across the soil to the starting point. The first run was therefore on loose soil. The loads were applied as before, but in most cases up to 10,000 lb., any further increase being prevented by the capacity of the apparatus. The depth of sinking was recorded for each new increment of load. The depths tested were as follows: 6, 9, 12, 18, 24 and 36 in. The application of pressure formed a "brick" underneath the loading strip. This compressed mass was not broken up, but was covered by loose soil when it was desired to increase the depth. In all cases enough extra loose material (1½ to 3 in.) was added so that at the end of the test the compressed material was at the depth recorded.

The curves in Fig. 5 show the distribution of vertical pressure for various depths of the clay mixture. It will be noted that they have the same general characteristics as the sand curves of Fig. 1. Each plotted point represents on the average 35 readings. In practically all cases there was quite a regular increase in the per cents of transmission as the load varied from 600 to 10,000 lb. per square feet, the maximum loads causing an average increase of 36 per cent in the transmission as produced by the minimum loads.

Tests on Loam—The tests in loam were run in exactly the same way as those on the clay mixture, but only on 6, 12, 24 and 36 in. depths. The loam contained enough moisture to cohere slightly by hand pressure and when the loads were applied a very solid brick was formed.

The following are the chief physical characteristics of the loam:

Gravel	22 per cent
Moisture	13.6 per cent
Weight per cu. ft., loose	73 lb.
Weight per cu. ft., packed	94 lb.
Angle of repose	40.5 degrees

Figure 6 shows the distribution curves for the various depths of loam tested. Each point represents on the average 43 readings. As in the case of clay, there was quite a regular increase in the per cent of transmission as the loads varied from 500 to 10,000 lb. per sq. ft., the average increase from minimum to maximum being 47 per cent.

Discussion of Results—Referring to the distribution curves of the three soils as shown in Figs. 1, 5 and 6, it will be noted that all the soils tested exhibit the same general characteristics, namely: a marked flattening of the curves with an increase in depth of soil, and a rather sudden bend (in the case of small depths) in the curves at the point where the loading strip just clears the weighing strip. As was to be expected, this bend is more marked in the sand curves, for sand on account of its lack of cohesion has less distributing power than other soils. Figs. 17 and 18 show a comparison of the distribution curves of the three soils for the same depths. A study of all these distribution curves (Figs. 1, 5, 6, 7 and 8) reveals the fact that when the loading strip was not over any part of the weighing strip, the per cent transmission was always less than twenty.

The curves in Fig. 9 show a comparison of the averages of all the results obtained for the three soils when there was no eccentric load. These curves corroborate the original contention that, inasmuch as sand gives practically no arching effect, it offers the worst conditions for loading and therefore gives the maximum vertical transmission of pressure.

In order to arrive at some definite conclusions in regard to the vertical transmission of pressure due to external loads, it was necessary to plot a series of curves from the maximum values obtained. These maximum values of transmission, as stated before, occurred for the highest values of loads as indicated in Fig. 10. Referring to this figure it will be noted that for depths smaller than 2 ft., sand transmitted the greater pressure, but that at greater depths the three soils (sand, clay mixture, and loam) gave practically the same per cents of transmission, which were always less than twenty. As the loads employed were such as are usually met with in practice, the value of these curves will be readily appreciated.

The results of the tests indicate that:

1. The per cent of transmission increases with increase of load.
2. For depths of earth greater than 2 ft. the per cent of transmission is always less than twenty.
3. For eccentric loads the per cent of transmission is always less than twenty when the loading strip is not over any part of the weighing strip.

BENDING TESTS OF KILN-DRIED STRUCTURAL TIMBERS.

Bending tests upon four kiln-dried Douglas fir beams and minor specimens cut from them were conducted recently at the Forest Products Laboratory of the U. S. Forest Service. Beams 1 and 2 were dried under high-velocity, low superheated steam, at a temperature of 225° F. for 8 days, 230° F. for the succeeding 7 days and 240° F. for the remaining 4 days; beams 3 and 4 were kept at a temperature 220° F. throughout the run. Steam was superheated for first 5 days when humidity was reduced to 70 per cent. During the next 4 days humidity dropped gradually to 35 per cent, where it was maintained during the remaining 7 days. Beams 1 and 2 had a modulus of rupture of 6,620 and 4,910 lb. per square inch, respectively and beams 3 and 4 a modulus of rupture of 4,740 and 6,160 lb. per square inch respectively. All failed by horizontal shear due to severe checking. The two beams which developed the low stresses did not come within the limit for a 1,600-lb. working stress for select structural Douglas fir. The results, however, are stated to be very encouraging for the development of the process for kiln drying Douglas fir beams in structural sizes.

The Harbor Commissioners of Quebec, Canada, recently awarded a $300,000 contract for the erection of a 1,000,000-bu. annex to their present grain elevators. The addition will be of reinforced concrete similar in construction to the completed portion of the structure.

PROPOSED STANDARD BIDDING PRACTICE FOR BUILDING CONTRACTORS.

A new standard of bidding practice for building contractors was suggested by Mr. H. W. Nelson of Moline, Ill., in a paper presented at the Atlanta, Ga., convention of the National Association of Builders' Exchanges of the United States. Mr. Nelson's plan, in brief, provides that the contractor demand compensation wherever asked to submit a bid in competition. Mr. Nelson's plan, as outlined in his paper, follows:

My form is based upon the following principles underlying competition: Estimating costs and establishing prices is an overhead expense involved in any merchandising, but the cost of doing so is generally nominal, if not insignificant, and the cost can be justifiably distributed. The cost of figuring or estimating work in accordance with special plans and specifications to meet each case, however, differs materially from establishing a price on each of a thousand hats, all made from the same material and from the same pattern. Therefore, my form is suggested to meet special conditions; to more justly distribute the cost of competition and estimating and to make each building bear its own proportion of the cost. My form is submitted with the thought that there are three main factors entering into the relations between the purchaser and the seller, viz.:

First—Quantity and quality of materials.

Second—Character of labor and personal service.

Third—Price to be paid for both.

The first factor, quantity and quality of materials, can be determined and definitely set forth in the form of plans and specifications, upon which the bidder can base his price. The second, labor and personal service to be rendered by the bidder or expected by the buyer, varies as much as human nature varies and cannot be so definitely or exactly set forth. The price, or third factor, can be based definitely upon the materials, but must necessarily vary upon the personal service, depending upon the value placed upon it by either the bidder or the buyer.

Therefore, when the buyer desires competition to enable him to make comparisons or decisions, based upon a combination of all three factors, competition which involves labor and expense on the part of the bidder, then the buyer shall purchase that competition at a fair and just price, just as he purchases anything else.

The buyer alone derives the benefit of competition, and no one buyer should pay for competition received by another—an abuse that exists under present methods. When and after the buyer has chosen his competition in a fair, unprejudiced manner, and has further paid a just and reasonable price for said competition, he shall be under no moral or other obligation to the bidders. He may make his own decision based upon his own opinion of the qualifications of the bidder or the bidder's price, or a comparison of both. A contractor should in no way be considered as an engineer, but solely in the light of a bidder and contractor capable of doing work in accordance with complete plans and specifications; and therefore, in every case where bidders are expected to bid in competition, they should be furnished with definite plans and specifications, covering the work to be performed as completely and specifically as commercially possible.

If a buyer cannot and will not provide complete detailed plans and specifications for the work, but wants estimates, measurements, figures or advice of a professional nature, then he, the buyer, shall consider such work in the light of a professional service and it shall not be considered proper, fair or just to ask for competitive price bids, but the charges for such professional service should be left for adjustment between the buyer and seller either before or after the work is done. Approximate estimates should not be considered binding upon either party involved. Now, my idea is this. Whenever a man asks you to give him a figure on his work, you should ask him if he wants a competitive figure. If he tells you he does, you should request from him a set of complete plans and specifications. If he has none you should send him to your architect or engineer.

You must make up your minds to be either one thing or the other. Either engineers or contractors. If your customer then gives you a set of plans and specifications and wants a competitive figure from you, tell him that you will be glad to give it to him provided he pays you for the time, money and talent required to give it to him, not otherwise. Now you ask: How much shall I charge him? Of course, strictly speaking, that is up to you. You ought to know. But in order to standardize and make a start, I have suggested a method. It is recognized that the cost of figuring is in proportion to the size of the job. That is the first factor. In fact, the percentage of cost of figuring reduces almost in exact proportion as the size of the job increases. The only mathematical way I know of to arrive at it correctly, is to work it out by taking the square root of the amount of the contract.

Now, if you choose any factor or number to multiply this square root number by, you will find that the percentage of your charge will be reduced automatically as the size of the job increases. You can set these factors yourselves. The electrical contractors can use 30 per cent of the square root; the plumbing contractors, 20 per cent, etc. You can establish one definite factor for each branch for universal use throughout the country, and then you are done. Or if your local exchanges are mixed, and its members are composed of all crafts, then you can adopt co-operative working arrangements, such as was done by the Quad City Builders' Exchange.

I did not perfect the form until last April, after thinking it over and working on it for years. Since last April until now I have been working with the Quad City Builders' Exchange to perfect their working arrangement, and I cannot say that we have yet finished. Yet, I understand that many contractors in our community are being paid for their bids. In fact, I absolutely know that some of them are. I don't expect that all of them are or ever will. But those who are being paid for their service need not worry about those who are not being paid.

But if you contractors established a new trade custom of this kind, which, it cannot be denied, is fair and equitable to all, you would accomplish many things. If owners had to pay for competition they would reduce it to a reasonable basis. They would base their decisions on other factors, as well as price. They would see to it that their architects and engineers made careful and conservative estimates, so as to avoid paying for competition twice or three times. If they had to pay in proportion to the amount of work done by bidders in estimating, they would see that their engineers prepared specific plans. It would elevate the character of engineering service and help the real architect. It would make each owner pay for just the competition he received and not compel him to pay for competition received by others. There are so many things it would do to better conditions that I could not begin to mention them all.

Last year, $2,000,000,000 was spent in erecting buildings in this country. It cost the contractors of this country $80,000,000 to furnish competition. Millions of dollars can be saved by you contractors if you will adopt better methods. A large portion of this waste is not only lost to the contractors, but is an economic waste, which the consumer pays. The public is the loser, because of your present methods. The ultimate consumer pays the bill. He will welcome any change in your methods that will save him an unnecessary expense, lower the cost of building work, and better the character of your work and your service to him. At first he is liable not to understand, but you will have to educate him. It is your duty, both to him and to yourselves. It is for the good of the ultimate consumer, the public, also for your good that I ask you to change your standards of practice, your trade custom.

SOME CONSTRUCTION FEATURES OF ADDITION TO UNION LEAGUE CLUB BUILDING, CHICAGO.

Unusual design and construction features were required for an addition to the Union League Club building, Chicago, completed last year. The new addition was made for the purpose of providing a swimming pool and gymnasium and the usual accessories. The work involved the placing of the swimming tank on top of the addition, and the supporting of two stories entirely independent of the old columns. The improvement was described by Frank E. Brown in a paper presented before the Western Society of Engineers and printed in the Journal of the society, from which the following notes are taken:

The original club building is an 8-story structure of ordinary construction supported on interior columns and bearing walls. The building on the south or rear 49 ft. of the lot is skeleton construction with steel beams and girders and cast iron columns, and, until the late addition, was eight stories in height. The club intends at some future date to tear down the present front building and put up a more modern structure. An existing plan of the complete future building contemplates making the present rear fireproof section a part of the final structure. With this in view, no extensive alterations to the present front building could be considered at this time and the location of the swimming pool and gymnasium were, therefore, restricted to the rear building. Three stories were added to the old building to provide the necessary space for the swimming pool and gymnasium.

On the eleventh floor is the swimming pool, which is 30 ft. wide and the regulation length of 60 ft., and has a water depth of 8 ft. and 6 in. at the plunge and 4 ft. at the shallow end. On the same floor are located a lounging room, a toilet, shower baths and a turkish bath, including steam, electric bath and massage room. In the penthouse over the turkish bath, is a large restroom provided with cots. Directly over and covering the entire area of the swimming pool is a skylight. This skylight is a double one—the top lights being built with a straight pitch to each side from the center of the pool, while the inner lights of amber glass are in the form of an arch. The abundance of lights provided by this skylight makes the pool especially attractive.

On the 9th floor is the gymnasium, which is 33 ft. and 6 in. wide by 97 ft. long, and has a clear ceiling height of 15 ft. The gymnasium is provided with the necessary apparatus for the various forms of exercise, including indoor ball and basket ball.

A large part of the 10th floor is taken by the lower part of the swimming tank. The remaining space is given over to locker and dressing rooms.

The framework required to support this addition involved some features not ordinarily encountered in building construction. The old columns were good for very little additional load, and, being cast iron, could not be reinforced to any great extent. Removing the old columns and replacing them with new steel columns was out of the question, as, besides the expensive shoring necessary, the old foundations were inadequate and of such character that they could not be easily reinforced.

The old foundations and the old cast iron columns below the seventh floor, however, were sufficient to support the new ninth floor. In the original design provision had been made for nine stories, six of which had been built as permanent and a seventh put on as a temporary story. Later the 7th story roof was strengthened and made the 8th floor, but the 7th story columns were left as originally constructed. This left them weak for the new 9th floor, and they were strengthened by filling and enclosing them with concrete, reinforced with hoops and vertical rods. The old 8th story columns and roof were removed and the new 9th floor built at the new level. This was supported with the exception of the east and west walls and adjacent floor areas on new 8th story columns resting on the old 7th story columns reinforced as stated above. The 9th floor was built of straight beam and girder framing with flat tile arch floor construction.

The 10th and 11th stories were supported entirely independent of the old columns. Eight new columns were used. These had to be located so they would clear the old foundations and not obstruct important rooms in the old building. In only one case could a column be located at a corner of the tank or in the interior part of the building and none could be placed in either the east or west walls. Considerable cutting and reframing in the old building was necessary in order to install the new columns. The old concrete floor slabs had to be cut, the old walls chased and the old spandrel and floor beams cut off, spliced and reframed to the new columns. Since seven of the new columns were located in the walls, some especially difficult cutting and reframing of old spandrels was required. In the east and west directions the old spandrel and wall beams served as braces for the new columns, but in the north and south directions new beams were added at all floors to tie into the old floor framing. In general, these braces were 12 in. channels laid flat and bolted to the top flanges of the old floor beams.

The new columns were located—three in the south wall, four in the north wall and one at the southwest corner of the swimming tank. This arrangement of columns, of course, necessitated special framework. The sides of the swimming tank were formed by plate girders, approximately 11 ft. deep. These support parts of the 10th and 11th floors and roof, as well as the 800,000 lb. of water in the tank.

The bottom of the tank was formed by 18-in. I-beams spaced 13-in. to 24-in. centers with $\frac{3}{8}$-in. plate over the entire area, riveted to the top flanges of the I-beams and to continuous angles on the sides of the girders.

A system of trusses in the 10th story around the four sides of the building was used to support the walls and floors above and the east and west walls of the 9th story and the adjacent 9th floor areas. The trusses in the east and west walls were framed to trusses in the side walls which cantilevered over the new columns located 7 ft. and 10 ft. in from the building lines. The trusses were built of double channel section placed 7 in. back to back and laced.

The trusses were set 6 in. eccentric with the columns. This could not be avoided as to have put the trusses on the center line of column and used brackets for supporting the walls, would have taken valuable space in the 10th story and interfered with the elevator clearances. The new columns could not be moved further out because on the south it was necessary to clear off the lot line and on the north it was undesirable to cut entirely through the old bearing wall below.

Lateral bracing was put in at the 10th and 11th floors between the wall trusses and the tank girders. The lateral pressure of the water in the tank was considered in determining the amount of bracing required for the top flanges of the girders.

The penthouse and roof framing was supported on struts to the 11th floor and on the exterior walls. This framing was somewhat involved on account of the many different levels of floor and roof. The skylight was framed by light steel trusses and purlins. The upper skylight units were supported directly on the purlins while the lower or arched skylight was hung from the purlins and the bottom chord of the trusses.

The walls of the 10th and 11th stories were built with 4-in. brick facing backed by Dennison tile. Every fifth course of brick was a header course. The tile was used in order to lighten the loads carried by the trusses. In the 11th story, solid brick piers were used at points where the heavier roof and penthouse loads were supported.

Dog catching at Baltimore, Md., is done by contract. The Board of Awards of that city recently awarded a contract for the seizure and destruction of dogs at a bid of $1 plus $8,499 of the license receipts and fines received by the Collector of Water Rents and Licenses. The contract is renewable for a second year at $1 plus $7,999 of such license fees and fines.

AN ECONOMICAL KINK FOR JETTING PILES.

Contributed by H. B. McDermid.

Recently on a job where a large number of piles were to be driven, the superintendent of construction hit upon a scheme to reduce the amount of water used, and still obtain satisfactory results. By experiment he determined the right size pipe necessary to produce the hole for the piles he was using. Then after finding he needed about a 3½-in. pipe, to produce the right sized hole, he had the blacksmith draw down one end of his pipe to a smooth nozzle, with about a 1-in. to 1¼-in. opening. This greatly reduced the amount of water flowing, but as the outside of the pipe remained the same, the same size hole was jetted, as would have been done had the pipe been left the same size throughout.

In practice, the pipe, with hose connection at top and nozzle at bottom, is hung vertically in the leads of the pile driver, the water turned on, and the pipe lowered till the nozzle has washed away enough earth to get a good hole started. It is then lowered into the hole, where the high velocity of the jet rapidly cuts away and washes out a hole, whose size is governed solely by the size of the supply pipe to which the nozzle is attached, as the water must flow out of the hole, on the outside of pipe, and so cuts a hole proportional to the area of the pipe used. Reducing this necessary pipe size to the small nozzle reduces the amount of water used, increases the velocity of the stream for an equal amount of water used, and incidentally reduces the amount of mud and water underfoot, for the crew to work in. Slowly raising the pipe up and allowing it to gently chug down, further each time, greatly increases the speed of the cutting.

32 COMPLETE CITIES TO BE ERECTED FOR U. S. GOVERNMENT.

Plans have been made and locations are now being selected for the 32 towns to be erected by the U. S. Government for mobilization camps for the new army of 1,000,000 men. Each camp will be of sufficient size to provide for about 22,000 soldiers and will be a complete city in itself. As soon as the camp sites are chosen the surveys will be made and contracts will be let. The construction work will be done by contract, under the supervision of Army officers.

To direct this undertaking, Col. I. W. Littell, of the Quartermaster General's Division, Washington, D. C., has been placed, by order of the Secretary of War, in general charge of cantonment construction. Col. Littell has already begun organizing his forces for the work.

It is estimated that 600,000 M ft. of lumber will be required, and arrangements are being made to secure this in all parts of the country, preferably in the section where the camps will be located. Each of the 32 cantonments contain about 2,000 houses. These will include quarters for the men, officers' quarters, kitchens, mess halls, bathhouses, storehouses, and all the various buildings needed for housing the troops and providing for the varied activities of a big camp. Most of the buildings will be long, 1-story structures, with some 2-story houses. They will be of plain construction but will be of modern type, and the plans and sanitary arrangements will carry out the most approved methods. They are expected to be the best arranged, cleanest, and most up-to-date barracks yet erected.

Each town will cover about 720 acres, a little over a square mile, and this does not include the large area required for drill grounds at each camp.

The contractors who are to do the construction work will organize their own forces of carpenters, laborers, etc., but the building will be done under the direction of Army officers. Several officers from the Quartermaster's Department, Government inspectors, timekeepers, foremen, engineers, plumbers, etc., will be stationed at each camp town, and Col. Littell has already begun to arrange for the men required for this work.

In addition to the 32 camp towns, the Quartermaster's Department will erect groups of warehouses at points where Army stores are to be concentrated. The exact number and location of these has not yet been determined, as they are to be erected to meet the needs of the Army as they arise.

STANDARD FORM CASTINGS.

Standard form castings and form bolts are used by the Chicago, Milwaukee & St. Paul Ry. in its concrete construction. Figs. 1 and 2 illustrate these castings. The casting shown in Fig. 1 is used in conjunction with wire ties made of No. 10 annealed wire and is held in place by a ¾-in. rod, threaded at both ends, which extends past the vertical 3 x 6 studding and between two horizontal girts against which it is held and tightened by means of a nut and cast washer. No boring is required in timber except through the form boards themselves. The castings are allowed to remain about 2-in. back from the face of the form, and the rods are readily unscrewed and withdrawn when the forms are taken down.

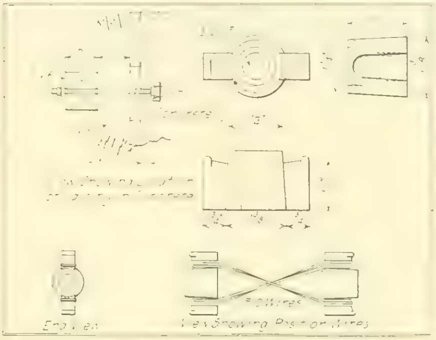


Fig. 1.

In practice, instead of the wiring being done within the forms, ties of the requisite length are made up and twisted on the frames outside. These ties and castings have been used for a number of years on all the concrete construction work and proved very satisfactory.

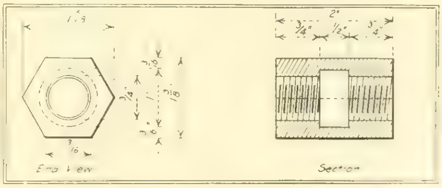


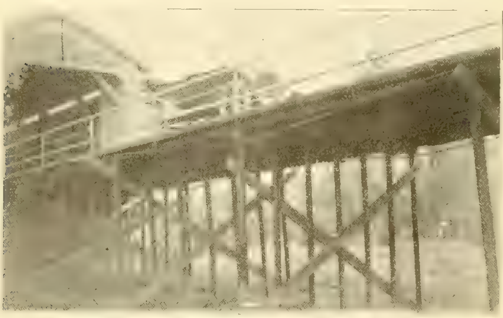
Fig. 2.

On thin walls it is sometimes found convenient to use castings shown in Fig. 2, the casting simply serving to form a socket for rods extending from either side of the form. L. D. Hadwen is engineer Masonry Construction, Chicago, Milwaukee & St. Paul Ry.

Test of a Zinc Borate Paint.—A small roof section covered with shingles painted with a zinc borate paint has just been tested at the U. S. Forest Products Laboratories for its fire-resistant properties, after having been exposed to the weather on the roof of the laboratory for nearly three years. Other shingles freshly painted with the same paint were tested in comparison. The results show that the paint had resisted the action of the weather without losing its fire-retarding properties to any marked extent. A close examination of the exposed portion of the shingles showed that the paint was in first class condition. It was concluded, therefore, that a zinc borate paint has excellent lasting qualities and that it retains its fire-retardant properties for at least three years.

TRESTLE APPROACH SUPPORTED IN GAS PIPE.

An ingenious method of bracing and supporting a trestle approach was employed on an Adams County, Indiana, bridge. The bridge, a 100-ft. covered structure, had a 75-ft. trestle approach of 6-in. I-beams carried on gas pipe piling, braced as shown in the accompanying illustration. The old bridge and approach were replaced last season by a 203-ft. structure made up of two riveted low truss spans.


Trestle Approach Supported on Gas Pipe.

Rapid Method of Kiln-Drying Eastern Hemlock.—In the course of cooperative experiments which are being conducted at the Forest Products Laboratory at Madison, Wis., by the Forest Service and the Northern Hemlock and Hardwood Manufacturers' Association, a rapid method of kiln-drying eastern hemlock has been developed whereby shiplap can be dried green from the saw to shipping weight in 48 hours and the 2-inch plank in six to eight days. One carload of shiplap and 2-inch stock of various widths has already been dried in the course of the experiments. All of the material came from the kiln in excellent condition and there was practically no loss due to drying. As a resultt of the demonstration a large lumber company is negotiating the erection of kilns to operate by this method and it is expected that other plants operating in hemlock will also adopt it.

Outfit for Small Concrete Jobs—A typical outfit of the Chicago, Milwaukee & St. Paul Ry. for small concrete work comprises the following:

1 Concrete mixer.
10 Wheelbarrows.
1 Cant hook.
50 Ft. 1-in. water hose.
1 Small track jack.
1 Combination vice.
1 Hand axe.
1 Double-bit axe.
1 Sheet pile pounder.
1 Timber bar.
1 Crosscut saw.
1 No. 4 sand screen.
12 D. H. S. P. No. 2 shovels.
6 Pairs knee boots.
1 D. H. spade.
1 8-lb. sledge.
1 16-lb. sledge.
1 8-ft. straight edge.
1 Grindstone and frame complete.
4 Claw hammers.
4 Pairs carrying hooks.
2 Heavy mortar hoes.
2 ⅞-in bridge augers.
3 Tubular lanterns.
1 Single-bit axe.
2 Water barrels.
6 Heavy galvanized water pails.
1 Gasoline-driven diaphragm pump.
1 Pinch bar.
2 Combination nail pullers.
12 D. H. R. P. No. 2 shovels.
1 Measuring box.
1 Tool box.
1 Steel broom.
3 Common brooms.
1 Stonemason's trowel.
1 16-ft. straight edge.
1 Plasterer's trowel.
2 Pairs wire pliers.
200 Ft. 1-in. line.
6 Track chisels.
2 12-in. monkey wrenches.
2 18-in. pipe wrenches.
1 Set 8-in. double blocks for 1-in. line.

NEWS LETTERS.

St. Louis Items.

J. W. McMurray, who has been under the weather for some time, is up and around again. Mack took a trip to St. Louis the other day. Says he is feeling as good now as he ever did.

Dudley Smith is finishing his work at Litchfield, Ill. Will have 8 teams, machine and engine idle.

The work of extending improvements on the State Aid road, south of Jerseyville, Ill., has started. Three miles of the Jersey Landing road were improved last year, and three more miles will be reconstructed this spring. The contract for building three bridges in Jersey County has been let to M. C. Robinson of Girard. Four new bridges will be built immediately on the Jersey-Macoupin County Line.

Sam Hannefin will be through with his work at Murphysboro, Ill., in a few days.

D. A. McMillen, President of the McMillen Contracting Co., Old Colony Bldg., Chicago, was a visitor last week. This company just started a contract putting in a three-mile coal spur for the Chicago & Northwestern R. R. near Benld, Ill.

Russell & Costello Bros. have started work on a big job at Russell, Miss.

Smith & Hannan are increasing forces and rushing work on the Wabash cut-off near DeWitt, Mo.

P. J. Murphy, Moberly, Mo., has 2 jobs of 10,000 yards each on the Wabash R. R. to sublet to small outfits. Free transportation over Wabash R. R. for outfits and labor.

Ross & Robertson, 626 Chemical Bldg., St. Louis, Mo., expect to finish their electric line work in Southern Illinois this month.

Quigley & Bonner Co. have opened an office at Carbon, Ind.

W. A. Gierke, who has a small sub-contract under Smith & Hannan on their Wabash work near DeWitt, Mo., says he will finish this work early next month.

Morris Wogan has started work on the Gulf, Mobile & Northern R. R. in Tennessee.

Contractors when in want of labor or work for their outfits write Koenig's Labor Agency, 612 Walnut St., St. Louis, Mo., or 503 Delaware St., Kansas City.

Columbus S. Jones, the boss stationmen, has subbed a nice lot of this kind of work from A. L. Cook on the Rock Island R. R. in Southern Iowa. John Jordan is in charge of this.

Strubel & Helmich, Alton, Ill., were awarded the contract for paving streets in Witt, Ill.

S. R. H. Robinson Co., St. Louis, Mo., put in the only bid for building and repairing the Government levee opposite Hannibal, Mo. There is approximately 259,000 yards of earth to be moved. Robertson's bid was 61 cts. per cubic yard.

Frank J. McCaughey of the J. J. McCaughey Co., Chicago, is scouting around the country looking up new work. This company can move 60 teams on to a job immediately.

A. B. KOENIG.

PERSONALS.

O. Laurgaard, Consulting Engineer, is a candidate for the elective office of City Commissioner of Portland, Ore.

W. E. Baldry, formerly city engineer of Dodge City, Kan., has been appointed city engineer of Topeka, Kan.

Charles E. Hewes for the past year city manager of Alhambra, Cal., has been appointed city manager of Alameda, Cal., at a salary of $4,000 per year.

John L. Harrison, for the past nine years supervising engineer in the Bureau of Public Works, Manila, P. I., has resigned that position and is at present located at Scribner, Neb.

J. H. Charlton, heretofore assistant engineer of the Virginian Ry., has been appointed Chief Engineer of the Boyne City, Gaylord & Alpena R. R., with headquarters at Boyne City, Mich.

Arthur C. Spurr has been appointed chief of the facilities bureau of the commercial development department of the Baltimore & Ohio R. R. to succeed A. C. Clarke, who was recently promoted to assistant engineer of surveys. Mr. Spurr was formerly connected with the operating department of the company in various capacities. He was transferred from Youngstown, Ohio, where he has been assistant yardmaster.

Mr. Ramsey is a graduate of Hobart College, Geneva, N. Y. He began his engineering career on the Lehigh Valley Ry. and subsequently was connected with the engineering corps of the B. R. & P. Railway, the Erie Railway, the Choctaw, Oklahoma & Gulf Ry., the West Virginia Short Line, the Western Maryland and several other railroads. From 1903-1906 he was construction engineer for the Tennessee Coal and Iron Company; later resident engineer of the Chicago, Milwaukee & St. Paul. After serving as general manager of the Spokane (Wash.) Fire Brick Company and Assistant City Engineer of Spokane, Mr. Ramsey took up private and consulting engineering practice at Orlando, Fla., later becoming city engineer and highway engineer for Orange, Osceola and Seminole Counties. He has had a great deal of highway construction under his direction, and has a wide acquaintance and high standing among members of his profession. The Dunn Wire-Cut Lug Brick Co. now has eight engineers on its regular staff.

Jenks B. Jenkins, valuation engineer of the Baltimore & Ohio Railroad System, has been commissioned a Major in the engineering division of the United States Army and expects to receive orders in the near future to go to France. Nineteen assistant engineers and other employes of the valuation department of the railroad have applied for commissions in the engineering branch of the service or have enlisted in the Army and Navy since the call for troops was made. As these men are for the most part technically trained, officials of the railroad expect that their services will be forthwith accepted, which will mean, of course, that the valuation work which has been in progress for nearly two years will be seriously interfered with temporarily. Mr. Jenkins will report to the chief engineer of the War Department. As plans for carrying on the valuation work with the limited force have not been decided upon, a successor to Mr. Jenkins has not been named. The assistant engineers of his staff will likely be distributed to other units of the military force.

INDUSTRIAL NOTES.

A. R. Topping has been elected secretary of the Walter A. Zelnicker Supply Co., St. Louis, Mo. Mr. Topping has been associated with this company for the past 11 years.

The Dunn Wire-Cut Lug Brick Co. of Conneaut, O., as soon as war was declared, wired Secretary of War Baker, tendering the output of the 68 paving brick plants in 12 states, which operate under Dunn license, for supply of wire-cut lug brick for immediate use in building military roads. The Dunn Company also offered the Government free advisory and inspection services of its corps of expert engineers in making surveys and constructing wire-cut lug brick roads designed for military purposes.

The Garford Motor Truck Co. has secured what is said to be the largest retail commercial car order of the year. It calls for early delivery of 34 Garford tractors to the New York City Department of Street Cleaning and it amounts to nearly $200,000. The tractors will be in operation on an average of 16 hours each day and haul loads in the neighborhood of 14 tons. After hauling trailers used in removal of ashes, street refuse and garbage during the day, the trucks will furnish the motive power at night for hauling and operating street sweepers and street flushing apparatus. In the winter, they will also be used for removing snow from the city thoroughfares.

Buff & Buff Mfg. Co., manufacturers of surveying instruments, Boston, Mass., has bought out R. Seelig & Sons of Chicago, a very old surveying instrument works, and has thereby established a branch shop in Chicago for better service for repairs of Buff instruments and all other makes. Mr. Seelig, the senior partner, remains in full charge of this shop, which has been equipped with modern tools and brought up to the Buff standard. Mr. Madison S. Jordan, who has full charge of the Buff & Buff branch office, moved from the Monadnock Block on May 15th to the new shop address, 231 North Fifth Ave., Chicago. A complete line of new Buff instruments will be carried there as well as a full line of field supplies.

The Copeland-Inglis Shale Brick Co., Birmingham, Ala., one of the largest and most important paving brick concerns in the South, has become a licensee of the Dunn Wire-Cut Lug Brick Co. of Conneaut, Ohio, and will henceforth make wire-cut lug paving brick. Beattie A. Inglis is Vice-President and Treasurer and W. Lawton Inglis is Secretary.

Planning and Management Quarterly Issue
of

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Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

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INCREASED OUTPUT FOLLOWING INCREASED WAGES IN THE FORD PLANT.

Experienced business men and engineers have frequently expressed the opinion that the higher the wage rates the lower the output of workmen and they have argued that high wages serve to "spoil" most workmen, that they become less amenable to discipline and are more given to drunkenness. Nearly every sweeping generalization about human nature is erroneous and needs qualification. Certainly men of low intelligence and little education are apt to lack both ambition and foresight. Such men may be "spoiled" by wages that are more than enough to provide the meagerest necessities of life. Thus in a recent "movie show" a Southern darkie, when promised "two bits" to go on an errand, said: "No, Ah thank you, jedge; I'se got two bits left."

With increasing intelligence comes increasing ambition for most men, and, provided the liquor habit does not control, a greater ambition causes greater exertion where it is evident that the exertion will be rewarded. So it follows that the average white American can be counted upon to increase his output if higher wages reward the increased effort. The repeated successes of piece-rate and bonus systems of payment have demonstrated beyond question the truth of this last generalization. Hence it required no deep discernment to infer that a decided raise in the rate of daily wages paid to factory men would spur them to a commensurately greater exertion. Nevertheless, factory owners have almost universally refused to act upon such an inference.

Somewhat more than four years ago Henry Ford made the spectacular announcement that the minimum daily wage in his motor car factory would thereafter be $5 a day. There was an immediate and enormous influx of workmen seeking positions under conditions that guaranteed the least man a "five per" income. The newspapers and trade journals throughout America not only gave unprecedented publicity to the announcement of this wage policy, but commented upon it editorially for months, and, in fact, have not yet ceased commenting. Hence Ford's high wage policy has come to be regarded by many as the greatest advertising scheme ever "put over." Others have claimed that it was a vast philanthropic act, and of no economic significance. Others have denounced it as an unfair method of drawing the best workmen away from competing factories. But rarely was there anyone who saw in the $5 minimum wage a device for increasing the output of the workmen, thus benefiting Ford as much as it benefited his men. There is abundant reason for believing that Ford foresaw the general effect of the increased wage rate, although possibly he did not anticipate the degree in which the daily output would be enlarged.

In February, 1913, with more than 16,000 men working a 10-hour shift, the Ford factory turned out 16,000 cars.

In February, 1914, with less than 16,000 men working an 8-hour shift, the Ford factory turned out 26,000 cars.

Hence, in spite of a decrease of 20 per cent in the working hours per shift, there was an increase of more than 60 per cent in the output per man! This is probably the most remarkable large scale increment in daily output per man that has ever occurred in any factory in so short a time. Make whatever allowance you reasonably may make for other factors, the effect of increased wage rates must stand out as the predominant cause of this unprecedented achievement.

Now, there is another feature of the Ford managerial policy that is perhaps more in need of exploitation than the effect of increased wages upon increased output. We refer to his systematized methods of arousing ambition in his employes. He not only encourages his men to marry and begin the purchase of their homes, but he makes their individual subsequent increments in wages depend largely upon their proven individual thrift. This involves what might be resented as probing into the private life of employes on the part of the employer, but, if done tactfully and within reasonable limits, such an examination of the employes' private affairs need not arouse resentment. In fact, does not the average man need and welcome an inspection that will serve to hold him to a course which he perceives to be wise? There is a vast deal of truth in the old saying, "Men are only children of a larger growth." Children often complain of parental discipline, yet rarely resent it when they recognize that its object is to build them into good men.

FORD, THE EXPONENT OF SPECIALIZATION.

In a recent article in "System" Henry Ford said:

> It's the man who is the ablest specialist in his line who wins the biggest success. * * * * The bigger the business the bigger the chance to harness up a lot of people with special ability. And in this idea of specialization lies the chance of perfection, and perfection means success. * * * * The great trouble in business today is that most people are so busy doing a variety of things that they have not time to get a real grip on any one thing. * * * * Now this principle of specialization applies to the small employer just as well as to the large. If a small manufacturer begins to do some special thinking he will get big ideas about his work, and as he follows those up in practice his business will grow accordingly. I started that way. I had an idea and I thought about it. I kept on thinking and I'm still thinking. * * * * My advice to every man is to read a lot and think a lot and work a lot.

In our last week's issue we commented on Ford's advice to "read a lot and think a lot." Let us now consider his advice to specialize a lot.

It is well known that Ford is a strong exponent of specialization. He makes but one size and type of engine and chassis for his motor cars; and upon this he has concentrated practically all his thinking for many years. To make it more cheaply has been his constant aim. The year ending July 31, 1916, he turned out 508,000 motor cars, at a total selling price of about $207,000,000, or about $400 per car; and the profits were almost $60,000,000, or nearly $120 per car. Evidently specialization is not a theory but a very profitable actuality with Henry Ford.

One of the open secrets of German efficiency in scientific research is specialization. An American engineer who was interested in geology called on several prominent German geologists, and came away greatly impressed by the fact that they were all specialists to the tenth power. One, for example, was "professor of trilobites" and had spent his life studying these ancient crustaceans. Aside from trilobites he knew little about geology, but there was not a known fact about trilobites that he did not know.

Whatever may be said against the practice of extreme specialization, it can not be denied that if it is accompanied by hard thinking and a fair degree of originality its fruits are often prodigous in importance.

For eight years Blake, the inventor of the rock crusher, let scarcely a waking hour pass without giving some thought upon the problem he had assigned to himself—the mechanical crushing of rock. He was rather unique in respect of the long time that he devoted to studying the problem before he made his first jaw crusher. But when at the end of eight years it was made, he did not change a single essential feature thereafter. It was a mechanical and commercial success from the day it was first put on the market.

Smith, "the father of geology," as a starter spent more than ten years thinking on the stratification of rocks and its significance. From an unknown English county surveyor he slowly came to be known as a specialist, and often a much ridiculed specialist. They dubbed him "Strata Smith," because he talked often and so much about stratification of rocks. Passing from an observation of the fact that the different colors of rock strata always occurred in the same order of superposition in his county, he was led to note a similar order in adjacent counties. Finally he began to observe that the fossils differed in different strata, and that he could predict what stratum would be found above or below another stratum whose fossils he had identified. Then he conceived the grand generalization that all stratified rocks had once been sands and slimes of ancient seas. Thus, by specialized observation and thinking, the obscure county surveyor Smith evolved into the celebrated "father of geology."

Dr. Lee Galloway, chairman of the educational committee of the National Commercial Gas Association, said at a recent convention:

> The great majority of men are kept from real exertion because they do not know the real nature of their work. They have never gone into the problems of their positions, and hence do not realize how much there is to learn before real responsibility can be put upon their shoulders.

To which we may add that even the relatively few who carry real responsibility often fail to appreciate the depth of their own ignorance. Beyond the best that any man has done there lies something better. Full realization of this fact comes only to such as have thought long and diligently on a single economic problem, aiming to find a better solution of it. Gradually there opens up a vista of possibilities of improvement, and yet more gradually comes a clearer view of some portions of the scene. Finally an "answer" presents itself, and then another, and still others—all as a result of specialized, long cogitation and observation.

The man who, by force of circumstances or by habit, never works long over any given thing, rarely gets out of the path that his predecessors have beaten; for intermittent, short time observation and thinking seldom disclose the inherent possibilities. As an example, take the case of the farmer who complained frequently about the scarcity and high price of fertilizers, but made no prolonged effort to solve the problem for himself. A neighboring farmer, by keeping the fertilizer problems on his mind and by reading a lot on fertilization, finally conceived the idea that the fallen autumn leaves in a nearby forest might serve his purpose at small cost; so he closed a 10-year contract with the owner of the forest, and for a nominal annual payment received permission to take all the leaves that accumulated. Their value as a fertilizer was many fold their cost delivered on the farm.

In order to acquire the habit of specialized and prolonged thinking, it is wise to make some seemingly narrow subject your "hobby." Read all about it. Study it in odd hours. Think about it on the train or as you walk. Get it into your system. Experiment with it, and learn more than any one else has learned about it. In the end you may have accomplished nothing startling in the way of increased knowledge, but you may have learned a great lesson and initiated an invaluable habit. The lesson will be this: Even the simplest subject has so many ramifications that a large book may not hold more than a fraction of what may be written upon it. Hence any energetic and persistent student of the subject will find enough to engage his best efforts, and possibly may add greatly to the sum of human knowledge about it. But of greater value than this valuable lesson will be the formation of the habit of specialized, persistent thinking, observation and experimentation.

TEACHING THE PUBLIC THE ANSWER TO: "WHY IS AN ENGINEER?"

By one of the greatest of misfortunes the name "engine" came to be applied exclusively to "steam engine." Then, quite naturally, the operator of such an engine was called an "engineer." Consequently the word engineer denotes engine operator or engineman to most people. Not all "educated people"—to say nothing of others—have a very clear idea of what is the highest and oldest meaning of the term engineer. Thus, a New Orleans paper, speaking of a meeting of the American Society of Mechanical Engineers, used this headline: "Enginemen to Open Convention Tuesday."

Mr. C. E. Drayers mentions this blunder in a very interesting letter that will be found in another column, and he urges engineers to take steps toward educating the public to a proper conception of what engineering is. He indicates what the Cleveland Engineering Society is doing to furnish the public with an answer to the question: "Why is an engineer?" That live society has issued, in magazine form, eight articles entitled "The Conquerors." The conquerors are not knights of the middle ages, nor indeed fighting men of any age, but just engineers—the conquerors of nature.

Read Mr. Drayer's letter and the description of the contents of "The Conquerors." Read it and then send 25 ct. to the Cleveland Engineering Society for a copy. Read the copy and give it to a friend to read, and keep passing it along. Get other copies and keep them in circulation, until all your acquaintances have learned something about engineers and engineering.

TWO MORE CITY MANAGERS AT $10,000 A YEAR.

Announcements of the appointment of Louis R. Ash as city manager of Wichita, Kans., and Gaylord C. Cummin as city manager of Grand Rapids, Mich., have come to us almost simultaneously. In both cases these engineers are to receive salaries of $10,000 a year as managers of cities of moderate size. The 1910 census gives Wichita 52,000 population, but it now has about 70,000. Grand Rapids had 112,000 in 1910, and has grown considerably since then.

Mr. Ash was formerly city engineer of Kansas City and is a member of the engineering firm of Harrington, Howard & Ash.

Mr. Cummin was city engineer of Dayton, O., and then became city manager of Jackson, Mich. He graduated from Cornell in 1904.

Eldorado, "capital of the new Kansas oil fields," with a population of less than 5,000, is said to have offered James E. Caton a salary of $4,000 a year as city manager. Mr. Caton is serving his third year as state auditor of Kansas.

Hot Springs, Ark., is the 46th city to adopt the city manager plan, but, so far as we know, has yet to select its manager.

This year the legislatures of five States—Kansas, North Carolina, Idaho, Montana and South Dakota—passed laws permitting municipalities to adopt the city manager form of government upon a referendum vote. It will not be many years before every state will have laws permitting cities to appoint managers in place of mayors, also dispensing with cumbersome city councils. There are about 1,000 cities of 8,000 or more population. Hence less than 5 per cent have thus far adopted the city manager form of government, but the success of the new plan has been so pronounced, particularly where civil engineers have been the managers, that it is not visionary to predict that fully 500 cities will come under "the management plan" within the next few years.

If engineers would act collectively and continuously in giving publicity to the merits of this new form of city government it would be possible to swing nearly every city into line within six years. Elsewhere we have commented on the publicity work of the Cleveland Engineering Society. It is this sort of organized effort that is most likely to awaken the public to the value of engineering services not only in designing, but in managing public enterprises, including that complex enterprise called a municipality.

EDITORIAL COMMENT.

Preliminary arrangements are reported under way between the U. S. Government and Panama, for the construction of military roads and a network of railroads which are expected to open up agricultural resources of Panama and prove of strategical value as a measure of defense. An expenditure of $40,000,000 to $50,000,000 is said to be contemplated.

H. S. Drinker, President of Lehigh University, speaking recently about war and the engineering student, said: "We indorse and are being guided by the judgment of General Wood, that the present situation does not yet call for retirement of students from their courses. On the contrary, we believe, especially in the case of students who should graduate this year, that they will be of far greater value to the Government if they finish the year's work."

This accords with the attitude of Chancellor Brown of New York University, upon which we commented last week.

Edward J. Pearson has succeeded another civil engineer, Howard Elliott, as president of the New York, New Haven & Hartford R. R. Increasingly the engineer is being recognized as capable of operating properties that engineers have designed.

LOGIC FOR ENGINEERS.

To the Editor: As an innovation the departmental rotation of engineering subjects is more than justified by the saving in time to the engineer. Moreover, it tends toward an effective concentration and co-ordination of valuable material which is impossible in journals of the more antique order. In its present form Engineering and Contracting becomes an invaluable, segregated reference library when bound according to departments. For these and many other reasons I most heartily endorse the change and extend to you my sincere congratulations on the origination of a publication idea of inestimable value.

I take this opportunity to congratulate you on your articles entitled "Logic for Engineers." Our modern professional man is generally shockingly ignorant of matters outside his own particular field. A broad and wholesome view cannot be had through a small and limited objective. Logic and philosophy should be required studies in our universities because of their broadening influence upon the intellect. My sympathy goes out to the shoemaker who has stuck to his last for forty years. Look him over—don't you think he needs a little sympathy? I have the same sympathy for an engineer who has done nothing but "engineer" for forty years. The shoemaker nails the sole to the engineer's shoe and many engineers believe that the shoemaker has found the right place for the soul. "Logic for Engineers" is a splendid antidote to "Bending Moments." A few hours spent upon this subject will generally result in the elevation of the soul from the place assigned it by the shoemaker. "Logic for Engineers" is not only a mental tonic but a source of a type of information and knowledge which may be applied in practical engineering. A better understanding of the methodology of knowledge, the laws of thought, and the content of consciousness must prove an invaluable aid in the solution of practical problems. If such articles result in spirited discussion, due to the different views held by the readers, this in itself is a splendid effect. My advice to the engineer and the shoemaker is, "Don't stick to your last so exclusively that the moss of specialization becomes so abundant that new brain cell associations become impossible."

Arvid Reuterdahl,
Kansas City, Mo. Consulting Engineer.

WHY IS AN ENGINEER?

To the Editor: We have heard much of the confusion of ideas in the minds of those not engineers as to the work of the engineer, but it took the actual occurrence to convince me that a great daily could make the mistake. A year ago when in New Orleans I saw an advance notice of the spring meeting of the A. S. M. E. on the front page of the "Picayune" headed "Enginemen to Open Convention Tuesday."

It indicates the need of a better understanding on the part of the public of the fundamentals underlying the practice of engineering. As the public becomes familiar with engineering, there will be a fuller utilization of the service engineers are trained to give.

To serve these ends is the purpose of a special publication, called The Conquerors, brought out by the Cleveland Engineering Society, assisted by engineering colleges and societies throughout the United States. Being a product of co-operation, it is presented as a contribution to the work of the National Committee on Engineering Co-operation.

A more complete account of the purpose of The Conquerors, a copy of which is being sent you under separate cover, is contained in the foreword. A list of colleges and other organizations assisting in the undertaking may be found on the page following the foreword. The idea of the publication, which might properly be called the high mark of the publicity work of the Cleveland Engineering Society, was conceived by Mr. A. J. Himes, Past President of the Society. The work of publishing was carried out by a special committee of which he was chairman and G. H. Tinker and G. S. Ward were the other members.

Inasmuch as the undertaking is entirely unique in the history of the engineering profession, it would seem to merit prominent notice in Engineering and Contracting. Thus also might the end for which we have labored be achieved, that it be placed in the hands of as many as possible. In Cleveland the members of the society buy as many copies as they can and give them to their friends and neighbors who are not engineers.

C. E. Drayer, Secretary,
Cleveland, O. Cleveland Engineering Society.

[The purpose of the special publication, "The Conquerors," as outlined in the foreword mentioned by Mr. Drayer, is as follows.—Editor]:

A Few Remarks to Engineers.

The community has practically no conception of the nature of your work and, therefore, ignores the fact that technical experience endows the engineer with a capacity for the development of public or private enterprise upon which he is not consulted. The lawyer, the doctor, the minister, easily advertise their efficiency through the personal services that they render to the community. The engineer is rarely thus advertised and this results in the inefficient and only partial enjoyment by the patron of the many services which the engineer can perform for him.

Do you desire to give the community the benefit of all your experience within and without the profession and incidentally enlarge the market for the sale of your technical skill? Do you not think that the engineer should be consulted on questions of public policy involving problems in which he is an expert? Are you interested in telling the prospective engineer what an engineer is before he undertakes to become one?

All this, and more, may be accomplished by introducing the engineer to his patron, the Public, thus acquainting the latter with the nature and importance of the service he renders and how that service may be enjoyed to its full capacity.

It's up to you, engineers, to make yourself known; no one else will do it for you.

To accomplish this end The Cleveland Engineering Society has issued in magazine form under the title of "The Conquerors" a series of articles on the work of the engineer, especially prepared by prominent men of the profession. It is written in a popular, nontechnical style, freely illustrated, in order to make interesting reading for your layman friends.

We earnestly request you to further this work of co-operation and publicity by distributing copies of this magazine among your friends. They will henceforth know better the value of your services and will not mistake you for an "engineman."

LOGIC FOR ENGINEERS.

VI. An Explanation of Mental Processes.

By Halbert P. Gillette

[The previous articles of this series are: I—Energy and Cause-Effect, Jan. 31; II—The Senses and Feelings, Feb. 28; III—The Categories of Energy (Number), Mar. 28; IV—The Categories of Energy (Space and Time), April 11; V—The Categories of Energy (Mass), May 9.]

What Is an Explanation? To explain a phenomenon philosophically consists in showing its kinship to another phenomenon that is not like it in every respect. Philosophical explanation consists in discovering likenesses, and it reaches its limit only when all likenesses have been identified. When, therefore, a class of phenomenon is of such extreme simplicity that it has no elements in common with any other class, it may be said to be an inexplicable or ultimate reality, as, for example, the four categories of energy. Motion is an inexplicable phenomenon; it is like nothing else.

Even highly educated men often confuse mere naming with explaining. The Indian medicine man who called typhoid a "bewitchment," the doctor of the middle ages who called it "distemper" and the educated physician of thirty odd years ago who termed it a "disturbance of the digestive and circulatory system" were all on about the same level of ignorance, each using names that explained nothing. But when it was finally shown that typhoid fever is caused by certain living micro-organisms in the intestinal canal, a real explanation was at hand; for here was an understandable kinship between the action of these germs and the action of other living things that feed upon and poison their prey.

Explaining Mental Action. The so-called explanations of the processes of observing, remembering and reasoning that are to be found in books on psychology and logic are, for the most part, mere naming of these phenomena in high sounding words, accompanied by unproved hypotheses that are delivered with great show of certitude and followed by small show of evidence in their support.

Mental processes can never be philosophically explained until kinship is established between them and processes that are not mental. Starting with this conception of the problem of explaining mental action, let us progress as far as we may in the present state of scientific knowledge.

Explanation of Sense-Records. We have already seen that each of the five sense organs is actuated by energy in some one of its forms. Taste and smell are chemically actuated. Touch and hearing are mechanically actuated. Sight is etherially actuated. In every case some form of motion actuates a sense-organ, resulting in chemical changes in the nerve, thus "transmitting" motion to a nerve-center where a sense-record is "inscribed" in the nerve-stuff.

If we expect to explain either a sense-organ or a sense-record we must do so by finding its analogue or likeness in the natural world or in the world of artifice or both. I have selected the world of artifice—the man-created world—in which to find the first crude explanations of sensation and of thought itself.

Prior to about 1840 there was no artificial device except the camera obscura, suggestive of the action of any of the sense. When, in 1802, Wedgwood published "An Account of a Method of Copying Paintings on Glass," the first step was taken toward photographing objects. But it was reserved for Niepce, Daguerre and Talbot forty years later to produce photographs by processes analogous to those now used. Thereafter in the combination of the lense of the camera and the sensitized plate there was had a device remarkably suggestive of the eye and its retina.

In 1877 Edison patented the phonograph, and thus made known another process of recording the effects of an invisible wave force that is "perceived" by one of the senses. The subsequent perfecting of a moving picture device by the same inventor may be mentioned as another step toward giving us a mechanical idea, as we may call it, a reproduction of things once seen.

Prior to these inventions it was impossible, it seems to me, to attempt even a crude explanation of the action of the senses and the sense-records that we term ideas or thoughts. But with these invented devices, coupled with our present knowledge of physics and chemistry, we may take a first step toward explaining certain mental actions.

The eye is a living camera whose lense throws a picture on a chemically sensitized plate called the retina. The rays of light change the chemical composition of the retina, but the change is not permanent. There is incessant renewal of the chemical composition of the retina. That the renewal is not instantaneous, however, is proved by the persistence of vision—the brief lingering of the photograph on the retina after the photographed object is removed.

The chemical change in the retina results in progressive chemical changes in the optic nerves, and these changes cause an energy-wave along the nerve to the brain. There the nerve-wave registers an impression on the brain, forming what may be termed a sight-record. Similarly the other senses serve to produce their respective kinds of sense-records.

Progressive Formation of Sense-Records. Every class of sense-record has been slowly produced. In this slow process of recording there is analogy to the exposure of a sensitized camera plate in a room. One short exposure either produces no discernible picture of objects or else a very dim picture of the brightest objects only. But let a succession of short exposures be made, and the negative will progressively record a more and more distinct picture of the objects. A sight-record in the brain is made progressively clearer in the same manner. This may be proved in many ways.

When a Caucasian first goes among Chinese "they all look alike," due to the fact that the Caucasian has not repeatedly seen Chinese.

To illustrate strikingly how a sense-record becomes clarified by repeated recordings, let an expert in any art be contrasted with a tyro. The skilled tea-taster can distinguish blends that are entirely beyond the perception of the ordinary person. Similarly the expert buyer of tobacco detects minute differences in flavor, whereas the non-smoking man can barely classify tobacco as "mild" and "strong." To the skilled musician there are harmonies and overtones unheard by the ordinary listener. The artist sees delicate variations in shades and can match colors with a precision wholly beyond the unexperienced user of colors.

There is a deeper truth than is commonly realized in the old saying: A man sees with his eyes only what is already in his mind.

Imagine the making of a phonographic record on wax, whereon a needle, impelled by a gently moving diaphragm cuts a slight groove. Let the needle pass again over the same groove, vibrating exactly as it vibrated before and at precisely the same time. The groove will be cut a trifle deeper in the wax. Each repetition will give a deeper cutting. Similarly, although of course chemically instead of mechanically, the sense-records are more "deeply" inscribed in the brain by repeated recordings.

In considering the progressive deepening and clarifying of sense-records, we must remember that we inherit certain sense-records that are already well developed; but that in our progenitors, far back, all classes of sense-records were at first vague.

Activating a Sense-Record. A sense-record, like a phonograph record, remains inactive until some energy stirs it into activity and causes it to "reproduce" or "play." The commonest cause of such "reproduction" is the presentation to the sense-organs of an energy-group identical with or similar to the original energy-group that made the sense-record. Thus the presentation of a rose to the eye causes the previously formed sense-record of a rose to "reproduce" itself and play synchronously or in harmony with the rose that is presented.

How such an automatic synchronization of a sense-record with an object is effected may be at least crudely explained. A tuning fork that is sounding a note will automatically cause a similar tuning fork near by to sound the same note. Similarly the vibration of corpuscles in the sight nerve that enters the brain may cause certain corpuscles of the brain to vibrate in unison, and these brain corpuscles thus made active are those "attuned" to such harmony. In other words, a given sense-record of a given sound replays in synchronism with the sort of nerve action that originally produced that sense-record.

In like manner every kind of sense-record is activated by the presentation of the kind of "object" (or energy-group) that originally made the sense-record.

This crude and simple explanation is obviously only a first step toward a more complete explanation of the process of observing or perceiving things.

It is apparent that so-called novel objects are not entirely novel save in the new combination of old elements. Thus, an animal that is of a species or genus new to the observer is like other animals in many respects and is also like inorganic objects in some respects. Its hair, for example, may be of unusual length and peculiar in color, but it is hair and it is colored. Although the combination is novel the elements are not, and they activate old sense-records of hair and of color.

The brain-stuff that forms part of one sense-record may also form part of other sense-records. Hence the foregoing illustrations must not be taken as implying the existence of numberless different and entirely distinct sense-records in the brain. On the contrary the evidence points unmistakably toward a sort of interwoven mass of sense-records, not only of those formed by one sense, but by all of the senses.

Perception of Objects. The act of perceiving an object (or energy-group) through any of the senses consists in synchronizing or harmonizing the object with a sense-record as above explained. Yet the very act of perceiving serves to develop a sense-record into more perfect synchronomism or harmony with the object. There is thus a veritable cause-effect ring, which is a paradox that seems inexplicable to one who lacks philosophic understanding of the endless chain of motions that constitutes all phenomena. A clearing up of the paradox will be relatively easy after further study of the subject of cause and effect.

Persistence of Active Sense-Records.. All sense-records exhibit a tendency to persist, that is, to contnue a forward movement of reproducing the record. This phenomenon is akin to the continued forward playing of a phonographic record, once the record has been set in motion. Let a child be taught a few verses until the sense-record has become deeply carved by repetition. Then name two or three words of any verse in sequence and the child will readily and speedily finish the verse; but will fail utterly in an attempt to recite backward from the given words. In general, the automatic "playing" of any sense-record proceeds in a forward direction; that is, in the same direction in which the record was originally produced.

It is this phenomenon of automatic forward "playing" of a sense-record, once it has been made active, that explains what may be called automatic deduction, or what psychologists call "association of ideas."

As will be more fully explained later, if there is a complex sense-record deeply "graven" in the mind of an animal or man, and if there is perceived an object that synchronizes or is in harmony with part of this complex sense-record, the rest of the complex sense-record automatically starts to reproduce. Thus, if a deer smells the odor of a lion, the rest of the complex sense-record relating to lions begins to reproduce, and the deer takes to flight to escape death, death of deer being part of the deer's complex sense-record relating to lions. It might properly be said that the deer deduces the presence of the lion and the resulting danger of death from the perception of the lion's odor. Yet psychologists have preferred to call this real, though primitive, form of deduction by another name—"association of ideas." We shall see that volitional deduction is also an "association of ideas."

How can the automatic forward playing of a sense-record be explained? The query may be partly answered by considering the phenomena of chemical action. Thus, once combustion has been started it continues. The heat evolved by the union of an atom of carbon with two atoms of oxygen, for example, serves to bring other atoms of carbon and oxygen to such a temperature that they unite and in turn give off more heat, thus extending the process of combustion. The activating of a part of a sense-record by direct perception, as above explained, serves to cause the immediately adjacent parts to become active, possibly through merely raising their temperature, but more likely as a result of a more complex physico-chemical action. Thus the activity spreads, very much as a flame flies along a train of powder from grain to grain. There is, of course, this difference: A living organism renews the particles of its substance that are destroyed by the chemical action of functioning; and thus "relays the train of powder" ready for another chemical reaction. This is well illustrated in that "sensitized film" of the eye, known as the retina, whereon pictures are photographed, destroyed and taken again in periods of time that are exceedingly short.

Automatic Generalization and Induction. "Generalization is the recognition of a character as being common to two or more objects," according to The Century Dictionary. This is equivalent to perceiving a characteristic or "mark" of a class, as when it is perceived that a tawny color is characteristic of lions. When, therefore, a number of sense-records made by different objects, as a number of different lions, are indistinguishable in respect of certain parts, a composite sense-record results. This composite sense-record is the class, and harmonizes with the parts that are similar in the different objects. Thus the composite sense-record that a deer forms of lions contains such sensible characteristics as the tawny color, the large head, the peculiar odor, and the loud roar. Such a composite mental picture, derived by perceiving many lions, may be called an automatic generalization.

It is not customary to use the word generalization except in connection with the "higher forms" of reasoning that man alone is presumed to display, but custom in this, as in many other uses of terms, often serves to obscure fundamental likenesses between phenomena. Give two similar phenomena different names, let the use of these different names be persisted in long enough, and most men will come to regard the two phenomena as being quite as dissimilar as their names.

Induction is the process of establishing a generalization. Hence if a composite sense-record of a class of objects is an automatic generalization, the process of building up such a composite sense-record is an automatic induction. Automatic induction is a process of repeated sensing of different objects until they become automatically classified according to their common resemblances.

If after seeing, smelling and hearing many lions at a distance, a deer finally witnesses the slaughter of one of its mates by a lion, the deer's sense-record of lions is enlarged to include the ferocious attack and resulting death of another deer. Let similar attacks be witnessed a few times, and the deer's automatic induction as to lions may be expressed thus: Every lion is tawny, with large head, peculiar odor, loud roar and kills deer.

It may be questioned whether the deer's generalization is so sweeping as to pass from a relatively few observed instances of attack by lions to a generalization that makes the attacking of deer a universal characteristic of lions.

I conceive that the minds of animals and of men invariably generalize every particular instance when first observed and that this is the inevitable consequence of the physical-chemical nature of the nerve centers that record perceptions.

As previously explained, a sense-record is an arrangement of the atoms and corpuscles of the nerve centers, chief of which centers is the brain. When an object is first perceived it makes a record in the nerve-center, and subsequent perceptions of the same object automatically cause the original record to replay in harmony. The subsequent perceptions may add somewhat to this sense-record, making it both more complex and longer. Because the replaying of a part of such complex sense-record causes the rest to replay, there results an automatic reproduction of the whole, provided nothing else interferes with the action. Hence the very nature of a sense-record makes it automatically reproductive of itself, so that to say "all lions that I have seen are tawny" is to say "every lion is tawny" until a lion appears that is some other color. If a black lion were to appear and be recorded in the composite sense-record of lions, the tawny color would cease to be one of the class marks of lions, but the other class marks would persist—the large head, the peculiar odor, the roar, etc. Not one of the class marks can be obliterated in any other way from a composite sense-record than by sensing an object having all the previously recorded class marks save that one.

This explanation of automatic generalization or induction removes the ancient mystery of the supposed mental leap from an observation of a few known objects of a class to an inference that all objects (past, present and future) of that class must have the same class marks that the few have. The fact is that the process of generalization is primarily automatic and always occurs during the formation of a composite sense-record of anything. The mind automatically starts with a generalization, as soon as it makes records of any class of objects. Then subsequent observations may narrow the generalization in some respects while broadening it in other respects. But until it is narrowed or broadened by observation, the mind invariably, because automatically, anticipates complete concordance of any member of a class with all the other members of the class, in so far as the class marks are concerned.

The mind when acting automatically never begins with "This and that lion is tawny" and thence to the generalization that "Every lion is tawny," but starts at once with the generalization that "Every lion is tawny" if all lions thus far seen have been tawny.

Automatic Deduction. In the preceding discussion the nature of automatic deduction has already been indicated.

When an object acts upon the senses it causes the sense-record of a like object to reproduce itself in harmony with the perceived object, and this activating of a part of the sense-record causes other adjacent parts to become active also. Hence automatic deduction is merely a sequel to a recognition, and is obviously dependent upon an original observation of greater extension than the object now perceived.

To illustrate, start with a deer's automatic generalization respecting lions: Every large, tawn, roaring beast of peculiarly pungent odor kills deer.

Now let the deer sense any part of this complex, as, for example, the odor, and it automatically deduces the rest; or, as some would say, infers it by analogy or arrives at it by instinct.

(1) Every lion has marks a, b, c, d, and kills deer.
(2) This thing has mark d (peculiar odor).
(3) Therefore this thing is a lion and kills deer.

The word "therefore" in this verbal statement merely indicates the ultimate cause of the subsequent conclusion that this is a deer-killing thing.

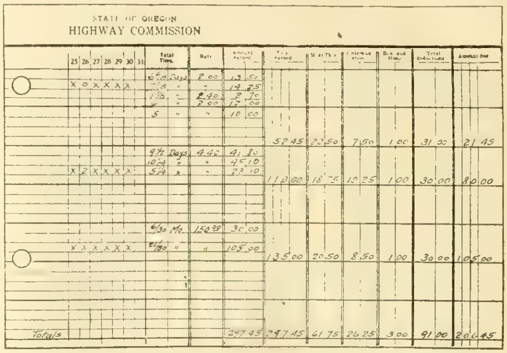
In the next article it will be shown that volitional deduction when correctly explained, takes precisely this form and order.

The Russian Duma is reported to have decided upon the construction of 60 new railroads to open up various districts in Russia. It is stated the funds have been found already to build 15 of these lines. A commission has been appointed to come to the United States and buy 2,000 locomotives and 40,000 freight cars.

The city of Nashville, Tenn., contemplates purchasing the Tennessee Central R. R., and improving and extending it. The State Legislature has authorized the city to use $5,000,000 of bonds for this purpose and for building terminal facilities.

COST KEEPING FORMS OF OREGON STATE HIGHWAY COMMISSION.

When the State highway work in Oregon was consolidated with the office of State Engineer a numerical system of cost keeping was installed. This method of accounting had previously been used on the construction of the Tumalo irrigation project by the State. It has been employed by the Oregon State Highway Department for the past two years, and also has recently been installed on road work in one or two other States. In order to facilitate the adoption of the system by the various county courts of Oregon, a bulletin describing it and its applications has been issued by Mr. John H. Lewis, State Engineer. Under the Oregon system every charge that requires the payment of money or the crediting back of money into a feature must bear an account number. The following details regarding the cost keeping forms employed by the Oregon Highway Commission are taken from the above mentioned bulletin.

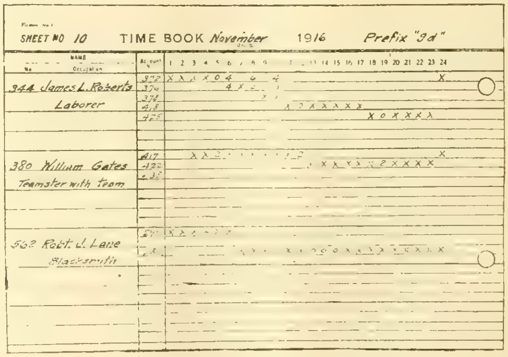


STATE OF OREGON
HIGHWAY COMMISSION

	25 26 27 28 29 30 31	Total Time.	Rate	Amount Earned	[illegible]	[illegible]	[illegible]	[illegible]	Total Deductions	Amount Due
		6¾ Days	2.00	13.50						
	X O X X X X	7⅛ "	"	14.25						
		1⅛ "	2.40	2.70						
		6 "	2.00	12.00						
		5 "	"	10.00						
					52.45	22.50	7.50	1.00	31.00	21.45
		9½ Days	4.40	41.80						
		10¼ "	"	45.10						
	X 2 X X X X	5¼ "	"	23.10	110.00	18.75	10.25	1.00	30.00	80.00
		6/30 Mo.	150.00	30.00						
	X X X X X X	21/30 "	"	105.00	135.00	20.50	8.50	1.00	30.00	105.00
Totals				297.45	297.45	61.75	26.25	3.00	91.00	206.45

Fig. 1—Time Book Sheet (Actual Size 8x5½ in.).

Figures 1, 2 and 3 show portions of timebook after having been completed and ready for payment of service. The sheets, when fastened together, form a continuous book, the time of the employe to the 24th of the month appearing on the first sheet and the balance of his time record on the back of the sheet, and in this manner running through the book so that when the timebook is opened a man's complete record of time follows across the two pages as though it were one long sheet.



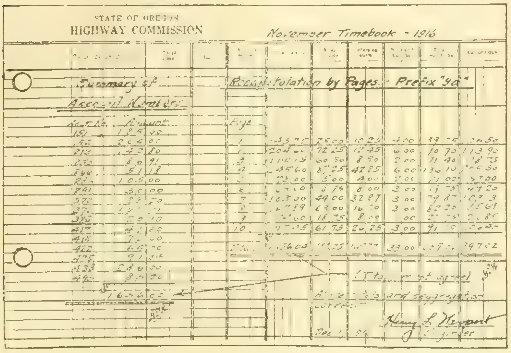
SHEET NO 10 TIME BOOK November 1916 Prefix "3d"

No. Name Occupation	Account No.
344 James L. Roberts Laborer	372 374 378 418 425
380 William Gates Teamster with team	417 422
562 Robt. J. Lane Blacksmith	

Fig. 2—Reverse Side of Time Book Sheet.

Figure 1 shows the badge number assigned to man, name and occupation of employe, account numbers under which he is working, the time to 24th of month; also it shows the sheet number of timebook, month, year and the symbol under which the work covered by this timebook is done.

When the mess is operated on work of some magnitude and changes in employes are frequent, it is sometimes considered of advantage to identify each man by a badge, which is given when he is signed up for employment and the number of which is entered opposite his name in the timebook. The men also are given notice that no one may enter the dining room without his badge, and that each man will be charged with every meal served while badge is in his possession. If he is to miss several meals at the mess and desires credit, he must report to the timekeeper and leave his badge before the first meal is served. The meals served while that badge is in the possession of the timekeeper he will not be charged with. The result in a great measure is the elimination of annoying arguments as to whether or not a man has due him credits for meals missed, when without the badge there might be considerable doubt as to whom meals were served. If these badges are lost a charge of $1 is made against the employe.



STATE OF OREGON
HIGHWAY COMMISSION
November Timebook - 1916

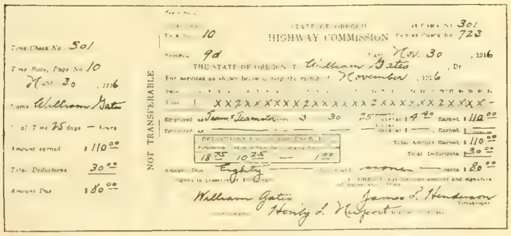
Summary of Account Numbers

Recapitulation by Pages. - Prefix "9d"

Fig. 3—Time Book Sheet, Showing Recapitulation of Time Book by Pages and Summary of Account Numbers.

Figure 1 gives a graphic example of the segregation of time. It will be found that these three men were employed on various features, and the plate shows how easily, by the use of numbers, the segregations are made, with the account number book as a key.

Figure 2 is a continuation of Fig. 1 and shows the manner of inserting rates and charges. It will be noted that James L. Roberts received $2 per day for all his work except that time spent fighting fire, which is paid him at the rate of $2.40 per day. The last item shows the method of handling monthly rates and at the bottom of each sheet, at the close of the month, is carried the totals of columns. In the "Amount Earned" column is carried the segregation of charges to each account number. In the "Total Earned" column is a total of each man's earnings for the period employed. "Meal Tickets" include charges for meals served at the camp. "Orders on Store" covers all purchases from camp commissary and mess supplies. "Rent and Hospital." It is customary on construction jobs to contract for the services of a physician and hospital facilities. A small monthly charge is made against each employe, ranging from 50 ct. to $1. "Total Deduction" column is self-explanatory, being the total of the three previous columns, "Amount Due" being the difference between "Amount Earned" and "Total Deductions."



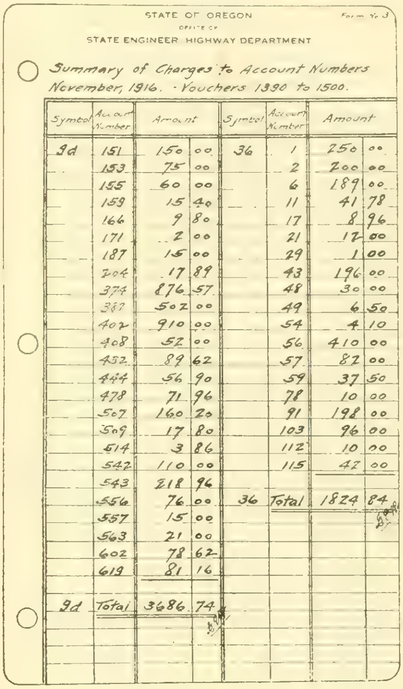
Time Check No 301
Time Book, Page No 10
Nov 30, 1916
Name William Gates
of Time 25 days — hours
Amount earned $110.00
Total Deductions 30.00
Amount Due $80.00

NOT TRANSFERABLE

STATE OF OREGON
HIGHWAY COMMISSION
Page No 10
Check No 301
Check No 723
9d
Nov. 30, 1916
THE STATE OF OREGON To William Gates, Dr
For services as shown below during the month of November, 1916
Time | X X 2 X X X X X X 2 X X X X X X 2 X X X X X X 2 X X X X -
Employed as Team & Teamster 3 30 25 $4.40 Earned $110.00
Total Amount Earned $110.00
18.35 10.25 — 1.00
Total Deductions $30.00
Amount Due Eighty —— none —— cents $80.00
William Gates
James L. Henderson
Timekeeper
Henry L. Newport

Fig. 4—Time Check Form Issued to Employes Desiring Wages Before Close of Month (Actual Size 9½x3⅞ in.).

At the close of the month each item is completed and the amount due extended, columns of the timebook sheets totaled and a recapitulation made by pages, as shown in Fig. 3. A summary of account numbers also is taken from the items of the timebook, the totals of each account number to which charges have been made during the month collected and the summary of the totals charged against each number listed, as shown. This total of account numbers and the total of the "Total Earned" (column 1) of the recapitulation of the timebook by pages should be the same. If the extensions of time worked are made correctly this is a pretty good check as to the correctness of the balance of the timebook. After this summary is made the one in charge of that particular unit which the timebook covers should certify to the correctness of items and segregations.



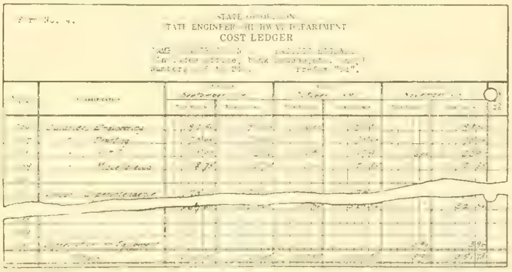
STATE OF OREGON
OFFICE OF
STATE ENGINEER HIGHWAY DEPARTMENT
Form No 3

Summary of Charges to Account Numbers
November, 1916. - Vouchers 1390 to 1500.

Symbol	Account Number	Amount		Symbol	Account Number	Amount	
9d	151	150	00	36	1	250	00
	153	75	00		2	200	00
	155	60	00		6	189	00
	159	15	40		11	41	78
	166	9	80		17	8	96
	171	2	00		21	17	00
	187	15	00		29	1	00
	204	17	89		43	196	00
	374	876	57		48	30	00
	387	502	00		49	6	50
	402	910	00		54	4	10
	408	52	00		56	410	00
	452	89	62		57	82	00
	444	56	90		59	37	50
	478	71	96		78	10	00
	507	160	20		91	198	00
	509	17	80		103	96	00
	514	3	86		112	10	00
	542	110	00		115	42	00
	543	218	96				
	556	76	00	36	Total	1824	84
	557	15	00				
	563	21	00				
	602	78	62				
	619	81	16				
9d	Total	3686	74				

Fig. 5—Condensed Form Cost Ledger Sheet. (Actual Size 4¼x7¼ In.).

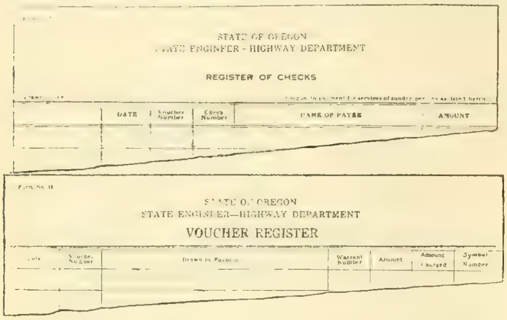
Time checks (Fig. 4) are issued by the timekeeper to the employes when services are terminated. When a time check is issued the time in the timebook should be closed in the same manner as would be the case ordinarily at the end of the month, and a notation entered "Time Check Issued," or, if no rubber stamp is provided, the notation in large blue pencil "T. C." is sufficient. On receiving payment on time check the employe endorses the back of the time check as a means of identification.



STATE ENGINEER HIGHWAY DEPARTMENT
COST LEDGER

Fig. 6—Cost Ledger Sheet for Large Projects. (Actual Size 9⅜x12 In.).

At the close of each month, or other periods when bills are assembled for payment, each item to receive payment should be accompanied by the proper account number to which it is chargeable, together with a prefix covering that special section of the project. The items making up these individual charges are listed on a ruled sheet of paper and totaled. As a check against the items of each section the amounts chargeable to the section should be taken also in lump sums by vouchers. If this amount and the total of the units by features charged to that section agree a reasonably sure check is secured on the accuracy of the amounts. The totals charged against each account number are listed on a sheet of tracing or other thin paper suitable for a blue printing and ruled, as shown on Fig. 5. At the close of each quarter a summary of these totals is taken to that time and worked out in the same manner, totaling each feature separately. This gives the total charges of each item and feature to date.



STATE OF OREGON
STATE ENGINEER - HIGHWAY DEPARTMENT

REGISTER OF CHECKS

	DATE	Voucher Number	Check Number	NAME OF PAYEE	AMOUNT

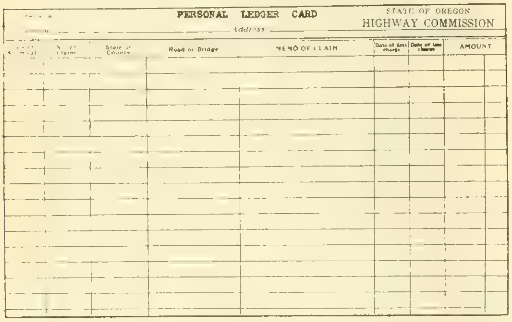
Form No. 11

STATE OF OREGON
STATE ENGINEER—HIGHWAY DEPARTMENT

VOUCHER REGISTER

Date	Voucher Number	Drawn in Favor of	Warrant Number	Amount	Amount Charged	Symbol Number

Fig. 7—Forms for Register of Checks and for Voucher Register. (Actual Size 8¼x10½ in.).



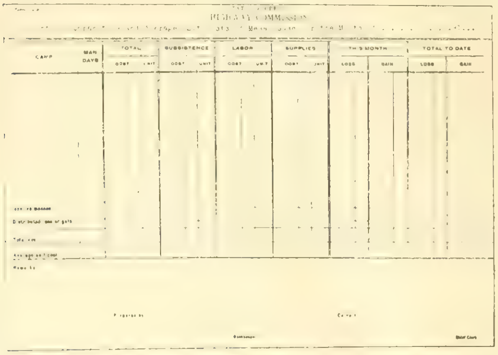
PERSONAL LEDGER CARD

STATE OF OREGON
HIGHWAY COMMISSION

Address

	No. of Claim	State or County	Road or Bridge	MEMO OF CLAIM	Date of first charge	Date of last charge	AMOUNT

Fig. 8—Personal Ledger Card. (Actual Size 5x8 in.)



HIGHWAY COMMISSION

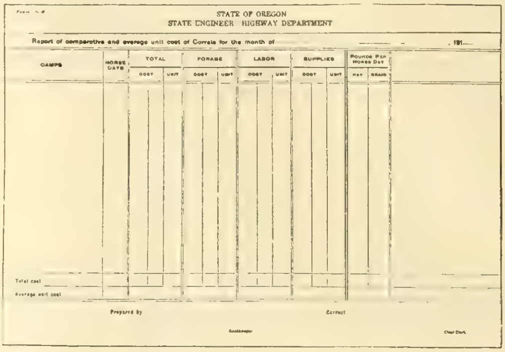
CAMP	MAN DAYS	TOTAL		SUBSISTENCE		LABOR		SUPPLIES		THIS MONTH		TOTAL TO DATE	
		COST	UNIT	COST	UNIT	COST	UNIT	COST	UNIT	LOSS	GAIN	LOSS	GAIN
Distributed loss or gain													
Total cost													
Average unit cost													

Remarks

Prepared by
Correct
Bookkeeper
Chief Clerk

Fig. 9—Report of Mess House Costs. (Actual Size 10½x8¼ in.)

While in most cases the small size of cost ledger sheet is preferable, there is a place for the larger form, as shown by Fig. 6, and on some work it may have advantages over the smaller form. This would apply on the larger project, where a general office with a full quota of assistants is maintained and condensing of records is not considered important. The plate shows the first numbers of "Camp Construction" feature and the final totals of the sheet. This sheet is followed in the cost ledger book by an insert printed on both sides, with space for entries for six months, and ruled in the same manner as Fig. 6, except that the space for classification and account number is left off. The classification and account number entered on Fig. 6 answers for all insert sheets which are bound into the book for as many months or years as the work may continue.



STATE OF OREGON
STATE ENGINEER HIGHWAY DEPARTMENT

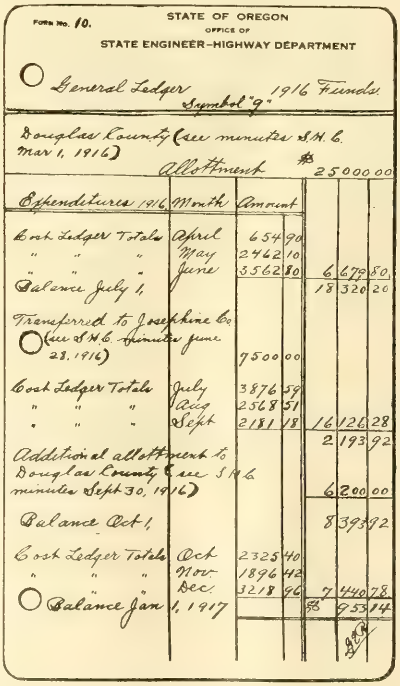
Report of comparative and average unit cost of Corrals for the month of ______ 191__

CAMPS	HORSE DAYS	TOTAL		FORAGE		LABOR		SUPPLIES		POUNDS PER HORSE DAY		
		COST	UNIT	COST	UNIT	COST	UNIT	COST	UNIT	HAY	GRAIN	
Total cost												
Average unit cost												

Prepared by
Correct
Bookkeeper
Chief Clerk

Fig. 10—Report of Corral Costs. (Actual Size 10½x8¼ in.)

The small sheet (Fig. 5) is in use by the Oregon State Highway Department and for the nature of the work in this State is considered to have many advantages over the larger form. A summary of costs by features is sent monthly to each of the men in charge of sections of the work. The original copy is made on a tracing paper and blueprints made from it for field use. This makes a small, compact record which is considered of importance. On public work the chief accountant is occasionally called upon to attend meetings of interested citizens who have a habit of asking questions on every subject imaginable



Form No. 10.

STATE OF OREGON
OFFICE OF
STATE ENGINEER—HIGHWAY DEPARTMENT

General Ledger 1916 Funds.
Symbol "9"

Douglas County (see minutes S.H.C. Mar 1, 1916)
Allotment $ 25000 00

Expenditures 1916	Month	Amount	
Cost Ledger Totals	April	654 90	
" " "	May	2462 10	
" " "	June	3562 80	6 679 80
Balance July 1,			18 320 20
Transferred to Josephine Co. (see S.H.C. minutes June 28, 1916)		7500 00	
Cost Ledger Totals	July	3876 59	
" " "	Aug	2568 51	
" " "	Sept	2181 18	16 126 28
			2 193 92
Additional allotment to Douglas County (see S.H.C. minutes Sept 30, 1916)			6 200 00
Balance Oct 1,			8 393 92
Cost Ledger Totals	Oct	2325 40	
" " "	Nov.	1896 42	
" " "	Dec.	3218 96	7 440 78
Balance Jan 1, 1917			$ 953 14

Fig. 11—General Ledger Sheet (Actual Size 7¼x4¼ in.)

connected with the work, and on financial matters they expect, and should be given, an immediate answer. To satisfactorily do this it is necessary to have practically a complete set of the cost ledger figures, and this is only possible and practicable by having them on a condensed form from which blueprints can be made, otherwise it would not be advisable to take the only set of books from the general office. Another advantage in the use of the smaller form is the small expense of printing and the lack of waste in its use.

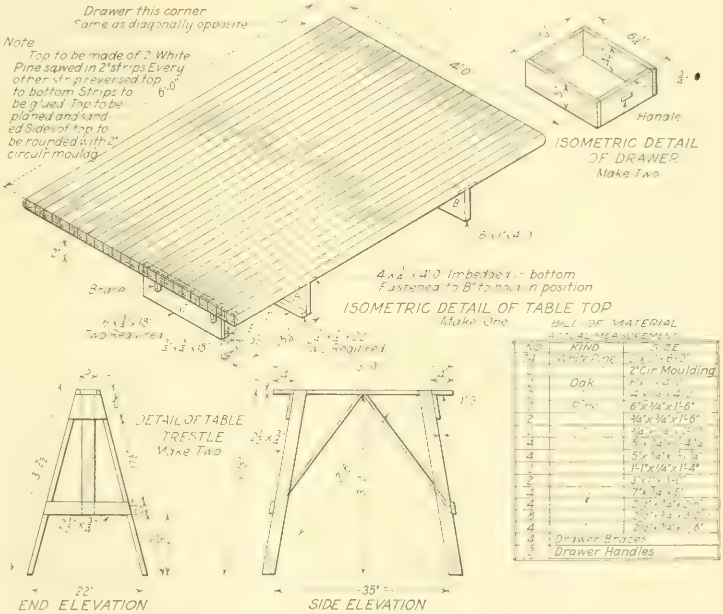
The cost ledger sheet shown on Fig. 6 is carried on heavier paper and it is not intended to make blue print copies of this record, although there is no reason why the form could not be made up on tracing paper and blue printed, the same as Fig. 5. This requires a little more labor in its preparation and it is suitable for larger projects.

Figure 7 shows Form No. 12, voucher register sheet, and Form No. 7 check register sheet. The nature of these records is shown by the headings on each form.

Vouchers are registered before securing signature, and exact duplicate of the original is placed in files, becomes the permanent record and never leaves the general office. The voucher register is totaled each month. Its total for the month should equal the total charges by account numbers to features for that month.

Payroll vouchers are made up from the field timebooks and checks issued. These checks are numbered numerically, each fund on which checks are drawn starting with No. 1, and a different colored check used to designate the different funds. Deposits for each fund are carried in separate banks to avoid confusion. The check register is totaled each month. Total amount of checks issued should equal amount of payroll vouchers.

The card shown in Fig. 8 is found more convenient in handling personal accounts than a bound or loose leaf ledger. It is arranged alphabetically in a box file or the drawer of a desk. At certain periods, usually quarterly, the names of those firms with whom there has been no dealing for the quarter and with whom, so far as is known, there will be no more dealings, are placed in a "dead file." This leaves a "working file," convenient to handle, and makes a very compact, easily kept record, and if carefully kept prevents duplication of payment of accounts.


Drawer this corner
Same as diagonally opposite
Note
Top to be made of 2 White Pine sawed in 2" strips Every other strip reversed top to bottom Strips to be glued Top to be planed and sanded Sides of top to be rounded with 2" circular moulding
6'-0"
4'-0
Handle
ISOMETRIC DETAIL OF DRAWER
Make Two
B
Brace
Two Required
Two Required
4 x 4 x 4'-0 Imbedded in bottom Fastened to B' to hold in position
ISOMETRIC DETAIL OF TABLE TOP
Make One
BILL OF MATERIAL
ACTUAL MEASUREMENT
KIND
SIZE
White Pine
2" Cir Moulding
Oak
Pine
6"x3/4"x1'-6"
3/4"x3/4"x1'-6"
1'-1"x1/4"x1'-4"
Drawer Braces
Drawer Handles
DETAIL OF TABLE TRESTLE
Make Two
END ELEVATION
22"
SIDE ELEVATION
35"

Drafting Table for Road Plans Used by Illinois State Highway Department.

Figure 9 is the messhouse report. The items on this form are self-explanatory. It is intended to show the status of messhouse operations from month to month as well as to date.

Figure 10 shows the form used for corral reports. The items show the status of corral operations from month to month.

Figure 11 shows a sample of the general ledger sheet covering allotments and expenditures in one section for the entire year. The form is small, but the space is ample and at all times gives a definite record of the status of funds under each section. At the close of each month a financial statement is made, listing accounts by feature and sections, which covers the ground very thoroughly. The original form is on thin paper from which blueprints may be made so that a duplicate set of records is available for field use, as well as an original, and a working set on blueprint paper in the office.

The U. S. Forest Service is taking steps for the organization of a forestry regiment to serve in France.

A PRACTICAL DRAFTING TABLE FOR ROAD PLANS.

Contributed by M. W. Watson, Assistant Road Engineer, Illinois State Highway Department.

It may appear somewhat elementary to discuss the design of a drafting table suitable for use in the production of road plans, but when proper consideration is given to the rapid strides in the field of road building which are now being made throughout the entire country, one can readily see that some thought might be given to the furniture and equipment employed in the preparation of plans for work of this character.

Many plans have been prepared for State-aid, township and county roads since the establishment of a State Highway Department in Illinois and it has been the aim of the department to adopt standard plans which are practical and economical for highway work. Numerous sizes and scales have been tried and after experimenting for several years it has been determined that the use of profile tracing cloth of the 10-in. width cut in sheets 5 ft. 8 in. in length is the most practical plan for road work in Illinois. Inasmuch as some 85 per cent of the roads have grades that are less than 4 per cent, the use of a wider plan is believed unadvisable and not only conducive of an increase in cost for materials, but renders the plans burdensome to the engineer in the field.

The plan and profile are drawn on the same sheet: the scale adopted for the plan being 1 in. equals 80 ft. longitudinal and 1 in. equal to 40 ft. lateral; that adopted for the profile being 1 in. equals 80 ft. horizontal and 1 in. equals 8 ft. vertical. The cross sections, being seldom used except for computing earthwork, are drawn in pencil only on tracing paper rather than on cloth and the scale used is 1 in. equals 4 ft. both horizontal and vertical. The sheets are limited to 5 ft. 8 in. for the purpose of filing and blue printing.

The length of 5 ft. 8 in. was brought about by the fact that the department, at the time the standard was fixed, possessed a drop light blueprint machine that would not admit a longer sheet. Since that time a continuous blueprint machine has been added to the equipment and the plans could be made continuous, but experience has shown that filing plans in rolls is not satisfactory, owing to the space required. Therefore, a system of vertical filing has been adopted for road plans which makes it necessary to continue the sheet method.

The average engineer, or engineering department, is limited in the size of office room, thus rendering it important that the drafting table be so designed as to occupy a minimum space. The Illinois Highway Department practice is to provide a table suitable for the use of two men working on opposite sides. This method has some advantages and some disadvantages. The main advantage occurs when two men are working on the same project, each checking the other's work, thus permitting a conference across the table. The main disadvantage lies in the tendency to unnecessary conversation between the men, but this can be prevented when adequate supervision is provided. The design shown in the accompanying cut provides for the minimum size that is practical when plans of the dimensions previously indicated are used. The table is of sufficient length to take care of the entire length of plan and of a width satisfactory to permit work on both sides, together with space for ink bottles and instruments spread out in the center for both draftsmen.

Owing to the detached tressels the table is easily knocked down and transferred from one point to another and can be easily crated for shipment. One of the meritorious features of this table is that it can be constructed by an ordinary planing mill, or by a carpenter of average ability and the price is considerably less than that occurring in connection with a table of more complicated design. A number of these tables have been purchased from a local company for $12 each. Small drawers are provided on opposite corners of the table to permit the storing of instruments and computation sheets by the draftsmen, but they do not contain sufficient room to permit the storing of plans and charts, thereby creating confusion in filing plans and the attendant loss that would occur if a large drawer space were provided. Tables of this design are used in the main office of the State Highway Department at Springfield and in the offices of the seven division engineers, and up to the present date have proven satisfactory.

If plans of a design other than those of the Illinois State Highway Department are used, very little difficulty will be encountered to change the designs of this table to meet any specific case.

The work of the Illinois State Highway Department is under the direction of Mr. Wm. W. Marr, Chief State Highway Engineer.

BICYCLE FACILITATES RAPID FIELD WORK.

A bicycle equipped with a standard make of cyclometer proved useful in rapid survey work, according to an article by Mr. Leslie H. Owen in the Proceedings of the Australasian Institute of Mining Engineers. The cyclometer was designed to register distances, in miles and tenths of miles, but instead of using one striker, eight were employed, so that for each revolution of the bicycle wheel eight impulses were given to the vanes of the cyclometer. Ignoring the decimal point the reading is in chains instead of miles. An ordinary level book was used for field notes, the following headings being employed: (1) Total distance; (2) Net distance; (3) Geology; (4) Time; (5) Aneroid reading; (6) Reduced level; (7) Remarks. A wrist watch was used for noting the time, and an aneroid barometer, reading differences of 10 ft., was employed for altitude. It was found that after a little practice the average time required to record the cyclometer reading, the direction since the last reading, the class of country, the time, the aneroid height, the locality, and to offset by eye any physical feature, was about 50 seconds. Readings were taken whenever there was an appreciable change in direction or at other obvious points, according to the nature of the work in progress.

Three county road jobs in Mississippi advertised for bids last week call for an aggregate expenditure of nearly $500,000.

ENGINEERING ECONOMICS.[*]

General Features of Engineering Economics.

When determining, from the standpoint of economy, which is the best of a number of proposed constructions or machines, one should compute for each case the four following quantities, and their sums:

A. The annual expense for operation.
B. The average annual cost of repairs.
C. The average annual cost of renewals.
D. The annual interest on the money invested.

That one for which this sum is least is the most economic of all the proposed constructions or machines; but this statement is truly correct only when the costs of operation, repairs, and renewals are averaged over a long term of years; or else, for a comparatively short period of time, when the conditions in respect to wear and deterioration at the end of that period are practically the same for all cases.

The principal economic investigation that occurs in engineering practice is that of determining the financial excellence of a proposed enterprise. It consists in showing by proper calculations its first cost, the probable total annual expense of maintenance, repairs, operation, and interest, the advisable allowance for deterioration or ultimate replacement, the probable gross income, and the resulting net income that can be used in paying dividends on the stock or other profits to the promoters. Whether any proposed enterprise, after being thus figured, will prove profitable will depend greatly on the state of the money market, the size of the project, the probabilities of future changes in governing conditions, and the personal equation of the investor. Generally speaking, if the computed net annual profits on the total cost of the investment (over and above all expenses of every kind, including maintenance, repairs, operation, sinking fund, and interest on all borrowed capital) do not exceed 5 per cent of the said total cost, the project is not attractive; if it be as high as 10 per cent, the enterprise is deemed ordinarily good; and if it be 15 per cent or more the scheme is termed "gilt-edged." Small projects necessitate greater probable percentages of net earnings than do large ones; and any possibility of a future reduction of income will call for a high estimate of net earning capacity. Finally, the measure of individual greed on the part of the investor will be found to be an important factor in the determination of the attractiveness of any suggested enterprise.

Such investigations as the economics of an important project should generally be entrusted only to engineers experienced in the line of activity to which the said project properly belongs; for if they be left to inexperienced investigators, it is more than likely that mistakes will be made and money lost in consequence. The professional men who generally do such work are the independent consulting engineers; certain specialists retained on salary solely for this purpose by important organizations, such as railroad companies; and engineers who are regularly in the employ of large banking houses. The work involved is of such importance that it usually commands large compensation—as, indeed, it should; because to do it effectively demands not only long experience but also good judgment and a vast amount of mental labor, both in order to make oneself capable in general and so as to consider thoroughly all the points embraced by the special problem in hand.

This fundamental economic problem is often one of extreme complication, involving, perhaps, a determination of the character of the proposed improvement, a choice of sites or routes, a selection of uses, a consideration of æsthetics, an option on type or style of construction, a question of ultimate durability, a study of greatest possible convenience, a prevision of serious opposition, a prognostication of future conditions, an anticipation of prospective structural modifications, and a safe estimate of cost.

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[*] From a series of lectures delivered before the students of the School of Engineering, University of Kansas, by J. A. L. Waddell, Consulting Engineer, Kansas City, Mo.

General Features of Economics of Design and Construction.

Anticipating the Future—In all engineering work of both designing and construction, true economy necessitates a thorough consideration of future requirements and possible eventualities, also a provision for meeting the same. For instance, in designing a structure one should consider possible future additions of loading and how to accommodate them; and in construction one should anticipate delays, floods, storms, and other possible difficulties, and should prepare his programme so as to meet them effectively and without any unnecessary expenditure of time, labor, or money. Foresight of this kind is an important element of success in the career of every engineer.

Systemization—Quoting from the speaker's treatise on "Bridge Engineering," "The systemization of all that one does in connection with his professional work is one of the most important steps that can be taken towards the attainment of success." Moreover, it is one of the fundamental elements of economics in all lines of work.

Time Versus Material—Some designers in their endeavor to save a small amount of material expend a large amount of time, not only of their own but also of other people's, which time when properly evaluated is often greatly in excess of the cost of the material saved. Such economy as this is false; and its practice is unscientific.

Labor Versus Material—Similarly some designers in an endeavor to cut down quantities in their structures increase the labor thereon to such an extent that the material saved is worth only a small portion of the value of the extra labor expended. For instance, if one were to make a small pier hollow, the concrete thus saved would not be worth anything like as much as the cost of the forms required to construct the hollow space.

Recording Diagrams—The study of economics is greatly facilitated by the use of diagrams that record quantities of materials, costs of construction, times of operation, etc., for varying conditions. In general, it may be stated that American engineers do not use graphics for studying economics to the extent which is advisable; and that in this they might learn something from their European brethren.

Economics of Mental Effort—Almost nothing concerning this important subject is taught in our technical schools; and but little is known about it by practicing engineers. To be a truly successful engineer, one has need to study deeply the matter of how best and most economically to utilize his mental forces; how to accomplish the greatest amount of work with the smallest expenditure of effort; how many hours of work per day for long-continued labor will effect the largest accomplishment; to what extent men in various lines of activity should take vacations, and how these should be spent; what are the effects upon one's working capacity from the use of liquor and tobacco in both small and large quantities, etc. All these are economic questions of great importance; and they need to be given proper attention by every engineer who aspires to efficiency in both himself and his employes.

Again, the development of the factulty of concentration is an economic consideration of much importance.

Economics in Office Practice—There are many conditions in ordinary office practice that are susceptible of considerable improvement from the economic point of view—for instance, unnecessary conversation, useless duplication of labor, and lack of proper checking; but this matter is too complicated and lengthy to warrant more than mere mention in a lecture of this kind.

Economics of Manufacture—This is a subject of such complication and extent that it can merely be mentioned here; for upon it a large treatise might readily be written. It will suffice to say that the prime requisites are the prompt furnishing at all times of materials and tools; the keeping on hand of spare parts of machinery which are liable to breakage or wear; the proper upkeep of all machinery and apparatus; the systematic arrangement for carrying work through the shops, preferably always in one direction; the avoidance of duplication of labor; the prevention of errors, and the speed correction of those which unavoidably occur; the development of individual efficiency in all employes; the maintenance of a contented spirit among the workmen; and the constant and intelligent supervision of all work.

Economics of Construction—This subject like the one last discussed is of great complication, and in general principles the two have much in common. For instance, there should be prepared for each piece of construction an elaborate programme, indicating the various steps to be taken and how the work should be carried out. Diagrams in this connection are most useful. Again, there should be prepared a time-schedule for the completion of the various divisions of the work; and this should invariably be lived up to when it is possible.

There should be a pre-arranged schedule for the furnishing of all materials and supplies; adequate means for the transportation thereof should be provided; the workmen should be well housed and fed; and should be made comfortable and contented; disagreements between heads of departments should be prevented; all possible difficulties should be anticipated, and means should be at hand to meet and overcome them; ample funds should be provided for paying promptly all bills for labor and materials; liquor should be kept away from the workmen; and strike organizers and other troublesome people should be run off the job.

All these matters are directly concerned with the economics of construction.

Labor—The scientific handling of labor is an economic problem of the utmost importance, and a treatise could well be written on the subject. The principal desideratum is to keep the workmen well, happy, and contented; and the best ways to do this are to treat them kindly, make them comfortable, feed and house them well, amuse them in their spare time, don't work them too long hours, pay them by piece-work when practicable, listen patiently to their complaints, right their wrongs, see that they are well taken care of when they are ill or injured, and evolve, if possible, some feasible method of sharing profits with them. On the other hand, though, drive them hard and continuously during working hours, insist upon their putting in overtime when the conditions truly require it, discharge instantly all insubordinate or otherwise troublesome men, dispense quietly with the services of all shirkers, and insist that everybody put forth his best and most intelligent effort to effect the maximum of accomplishment in the minimum of time.

Waste—In all lines of activity the avoidance of waste or extravagance and the utilization of by-products are today burning questions; and upon their proper solution by American scientists will depend greatly the success of our country in its commercial struggle with the nations of Europe and Asia. This statement is just as true concerning engineering as it is of any other activity; and it is encouraging to see that a number of our leading technical institutions are inaugurating research departments for the furtherance of this object. Prominent among them in this work, the speaker is pleased to say, is the University of Kansas.

Efficiency Experts—A very new type of specialist in engineering is the efficiency expert—the man who takes hold of moribund factories and other decaying enterprises, studies them thoroughly so as to determine the raison d'etre for their decline, evolves the proper remedies for their troubles, puts them again upon their feet, and starts them upon the high road to success. It is mainly in little matters, apparently of small importance, that such concerns fail; and it requires a high development of unusual talent in an engineer to become a truly successful efficiency expert. Such work as his no one can deny being "engineering economics" in the truest sense of the term; and the specialty is surely destined to become more and more popular and important as the years pass by.

INSTRUCTIONS TO HIGHWAY ENGINEERS.

The following instructions for making surveys and plans for state reward roads are given in the recently issued biennial report of Frank F. Rogers, State Highway Commissioner of Michigan, for State Reward Roads in Michigan:

(1) In establishing center line of road, section and quarter corners must be found in place. If no permanent monument exists, corners must be established in accordance with rules of the Government survey and permanent monuments set.

(2) Stakes with hubs should be set 100 ft. apart along each side of the proposed roadway, uniformly 25 ft. from the center line of the same.

(3) Levels should be taken at each station: (a) on the center line, (b) on the hub at each side stake, (c) in the bottom of each ditch, if there are any ditches. Plus levels should be taken on railroad tracks, on the floors of culverts and bridges, in the beds of streams that serve as outlets for road ditches, and at such other points as the survey may deem necessary.

(4) The plan and profile should be placed on the same sheet, projecting the plan vertically above or below the profile. Angles in the line may be indicated by the use of broken lines or small circles, giving the bearings and distances in figures without attempt at laying out with a protractor.

(5) The plan must contain a description in sufficient detail so that the road can be platted on township maps. The description must refer to section lines, quarter lines, section corners, quarter corners. Exact location of point of beginning with bearings and distances of the survey to the terminal must be given. In case of angling roads, where center line crosses section or quarter section lines, the station and plus at intersection and the distance from such intersection to the nearest section or quarter section corner should be noted on the profile. Permanent monuments to be set on center line at all angles.

(6) One hundred feet to the inch horizontal and 5 or 10 ft. to the inch vertical are desirable scales. No smaller scale than 200 ft. to the inch horizontal and 20 ft. to the inch vertical will be allowed. Vertical and horizontal scales should always be noted on the profile.

(7) The profile must show at each station: (a) center line cuts and fills in figures, (b) the depth of each ditch or gutter in figures from the outer side hubs, (c) the distance in figures of the established grade above or below each line of side hubs. Tabulated cuts and fills on separate sheets are not desirable and will not be accepted in lieu of the profile. Cuts and fills should balance.

(8) Grade line should show elevation of finished road and not the subgrade. Points of change in proposed grade line should not be made abrupt, but angles should be rounded off with vertical curves. Avoid, if possible, the use of level grade line. At least 6 ins. incline to 100 ft. is desirable. Elevations of stations at change points should be given, referring to located bench marks.

(9) A complete working profile should show: (a) center line profile, (b) profile of each side ditch or gutter, (c) all the figures required to build the complete road as staked out.

(10) A typical cross-section should be shown. State law requires that turnpike be at least 20 ft. between and exclusive of side ditches with an average crown of 1 in. to 1 ft.

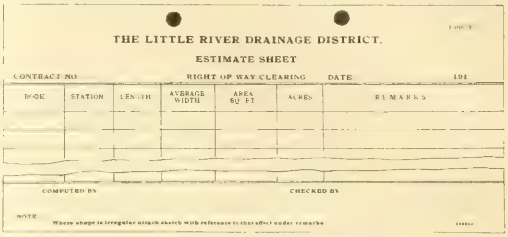
(11) At least three sets of plans must be prepared, one for filing with the township or county clerk, one for filing with the State Highway Department, together with application for reward, and one for use of commissioner or foreman doing the work. Surveys and engineers should provide themselves with application blanks for state reward roads and fill in description ready for the signing of the township board or county commissioners.

(12) All profiles must be approved by township boards or county road commissioners before filing with the State Highway Department.

METHODS AND COSTS OF SUPERVISING DRAINAGE CONSTRUCTION IN THE LITTLE RIVER DRAINAGE DISTRICT.

Contributed by B. F. Burns, Office Engineer, Little River Drainage District.

So many considerations enter into the matter it can be quite properly said that the supervising organization of each drainage district presents a separate problem and cannot be patterned exactly along the lines of that of any other district. The general conditions existing within the district, the possibility of locating the residency headquarters convenient to the work assigned, transportation facilities to and over the work, the character and thoroughness of the inspection contemplated, and whether or not engineers of proper attainments and ability can be secured and retained, in view of the usual working conditions, are all considerations that must be taken into account in planning to place an adequate and efficient organization for supervision of the construction work on a drainage district.



THE LITTLE RIVER DRAINAGE DISTRICT.

ESTIMATE SHEET

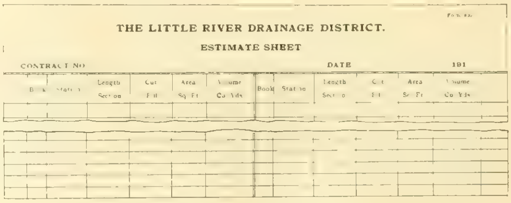
CONTRACT NO RIGHT OF WAY CLEARING DATE 191

BOOK	STATION	LENGTH	AVERAGE WIDTH	AREA SQ FT	ACRES	REMARKS

COMPUTED BY CHECKED BY

NOTE Where shape is irregular attach sketch with reference to that effect under remarks

Estimate Sheet—Right of Way Clearing (8¼ in. x 11¼ in.).



THE LITTLE RIVER DRAINAGE DISTRICT.

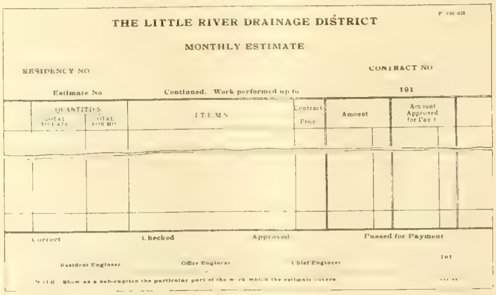
ESTIMATE SHEET

CONTRACT NO DATE 191

Book	Station	Length Section	Cut Fill	Area Sq Ft	Volume Cu Yds	Book	Station	Length Section	Cut Fill	Area Sq Ft	Volume Cu Yds

Estimate Sheet—Excavation (8½ in. x 11 in.).

The plan worked out for The Little River Drainage District, with its 30-mile diversion system and 624 miles of drainage ditches, contemplated the installation of 6 residencies; two to supervise the construction of the diversion system and four on the drainage ditches. No difficulty was had in locating the headquarters of each within a reasonable range of the work. The district is quite well traversed by railroads; in fact, no point within it is more than 6 miles from a railroad. A thorough inspection of all work was to be required. The force allotted the residencies on the diversion system was a resident engineer, instrument-man, rod-man, chain-man and such inspectors as might be required to look after the construction of levee embankments. On the residencies having the drainage ditch construction in charge the forces



THE LITTLE RIVER DRAINAGE DISTRICT

MONTHLY ESTIMATE

RESIDENCY NO CONTRACT NO

Estimate No Continued. Work performed up to 191

QUANTITIES TOTAL TO DATE	QUANTITIES TOTAL FOR MO	ITEMS	Contract Price	Amount	Amount Approved for Pay't

Correct Checked Approved Passed for Payment

191

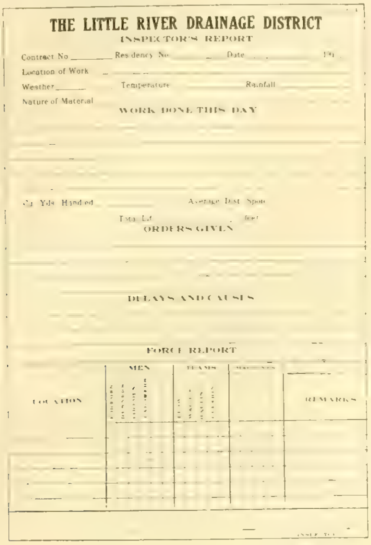
Resident Engineer Office Engineer Chief Engineer

NOTE Show as a sub-caption the particular part of the work which the estimate covers

Monthly Estimate Sheet (8¼ in. x 11 in.).

assigned each was a resident engineer, rod-man and a chain-man. No trouble was had in securing engineers having executive ability as well as engineering knowledge for the positions offered, as the work opened up.

The corps mentioned above was planned in contemplation of 26 of the contracts being planted simultaneously, but that did not work out. Several of the smaller contracts were planted prior to the sale of the district's securities and their work was well under way when the securities were disposed of and the general order given to begin construction work. In consequence of this there was some irregularity in establishing the residencies and always the limiting distances of travel, consistent with economy, could not be adhered to. However, as the progress of the construction warranted, the residencies were established until there were six handling the work very much as outlined. After a few months it was believed possible to handle the work efficiently with but five, by a slight rearrangement of the forces to give additional men to the residencies where territory was added. This arrangement was put into effect and is now being maintained.



THE LITTLE RIVER DRAINAGE DISTRICT
INSPECTOR'S REPORT

Contract No ______ Residency No ______ Date ______ 191
Location of Work ______
Weather ______ Temperature ______ Rainfall ______
Nature of Material

WORK DONE THIS DAY

Cu Yds Handled ______ Average Dist Spoil ______
Total Lift ______ feet

ORDERS GIVEN

DELAYS AND CAUSES

FORCE REPORT

LOCATION	MEN	TEAMS		REMARKS

Inspectors' Report (5½ in. x 8¼ in.).

General instructions covering the routine work, setting out the methods to be followed and the results expected were considered essential. Owing to differences in the nature of the work, one set of instructions was written for the direction of the engineers on the diversion system and another for those on the drainage ditch work. Naturally, situations arose as the work progressed that could not be contemplated when the instructions were written, and where these were of such nature that they could be covered by general instructions, additions to the original instructions are made by issuing an appendix.

In addition to the above mentioned instructions, each resident engineer was furnished with a Plan for Drainage—a pamphlet containing complete descriptions of the drainage ditches and canals, their sizes, locations, width of right-of-way, etc.—and a copy of the specifications, which embody the contract form.

An office room is provided at each residency headquarters and furnished with drafting table, filing cabinet, etc., and each corps is supplied with the necessary surveying instruments required in the work.

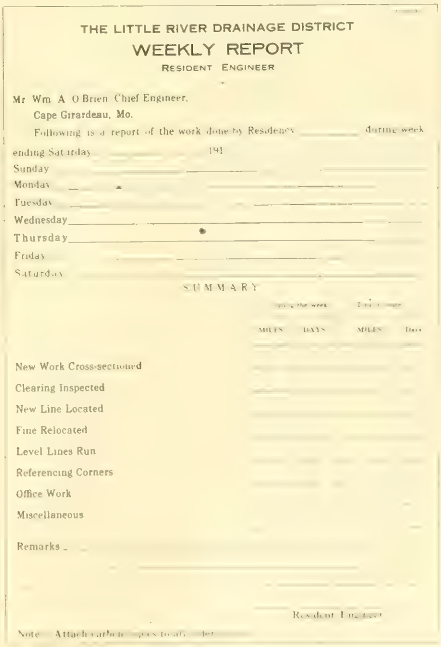
The books and forms supplied to each residency are as follows:

Engineer's field books.
Diary.
Estimate forms.
Inspector's daily report forms.
Weekly report forms for contractors' work.
Order forms.
Engineer's weekly report forms.
Pay roll forms.
Expense account forms.
Excavation tables.
District stationery.

Field books of the usual type were used at the beginning of the work, but, as notes had to be transmitted back and forth between the residency office and that of the chief engineer, the disadvantage in their use was early apparent and a loose leaf duplicating field book was substituted. With these in use carbon copies of the notes are retained in the book and the originals are detached and mailed to the chief engineer's office. The field book found to best suit our purpose is made by Geo. L. Kopp Co., New York. The added worth of a duplicating note book was demonstrated when one of our residency offices was destroyed by fire and the engineer was enabled to procure from the chief engineer's office copies of all of the notes pertaining to the work on his residency, which were required to carry it on, without delay.

It is required that each engineer keep a diary, noting in it each day any unusual happening or important matter, pertaining to the work under his jurisdiction, that may have transpired. Books of uniform size and make are furnished for this, and after the work is completed these will be filed in the main office and will no doubt afford a very complete and important addition to the records.

All estimates originate with the resident engineer. These he makes out in detail, showing the quantity of excavation between stations and the total, and the number of acres of clearing accepted—giving the stations between which the clearing was done—and a summary sheet, in duplicate, setting out the total quantities of excavation and clearing allowed, extended at the unit rates named in the contract, and making the usual hold back deductions. All of these he sends to the chief engineer's office, where the computations are checked and the duplicate summary sheet returned, approved, for his file. The contractor's estimate is made up in the office of the chief engineer and, unless there is an error in that of the resident engineer, corresponds exactly as to quantities and amounts.



THE LITTLE RIVER DRAINAGE DISTRICT
WEEKLY REPORT
RESIDENT ENGINEER

Mr Wm A O Brien Chief Engineer.
Cape Girardeau, Mo.
Following is a report of the work done by Residency ______ during week ending Saturday ______ 191
Sunday ______
Monday ______
Tuesday ______
Wednesday ______
Thursday ______
Friday ______
Saturday ______

SUMMARY

MILES DAYS MILES DAYS

New Work Cross-sectioned
Clearing Inspected
New Line Located
Fine Relocated
Level Lines Run
Referencing Corners
Office Work
Miscellaneous

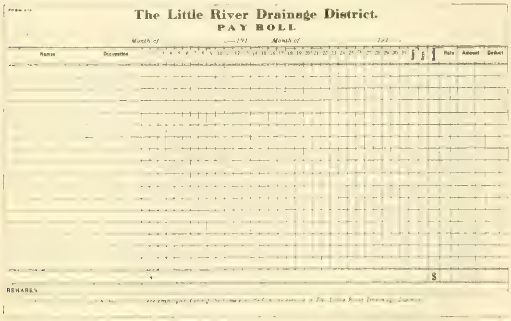
Remarks ______

Resident Engineer

Weekly Report of Resident Engineer (8 in. x 11 in.).

Where levee embankments are being constructed, inspectors are maintained, and each of these inspectors makes daily report to cover the operations of the machine or machines under his supervision. On these reports, in addition to the progress, delays, forces employed, etc., is noted the stage of water in channel or borrow pit, the condition of the material being placed in the embankment—if any movement of the material is noted after it is placed, the apparent cause—also, any other information pertinent to or of value in connection with the work.

Practically all the communications between the engineers and the contractors are in the form of directions or orders relating to the work. It is the practice to give all orders in writing and a form for that purpose is provided. All orders are written in triplicate; one for the contractor, one for the chief engineer, and one for the resident engineer. Where possible to do so the signature of the contractor or his representative is secured on each copy of the order as an acknowledgment of its receipt.



The Little River Drainage District.
PAY ROLL

Month of ——191 Month of 191

Names | Occupation | 1–31 | Rate | Amount | Deduct

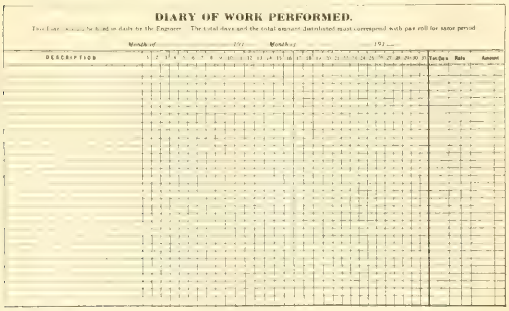
$

REMARKS

Front of Pay Roll Sheet (13½ in. x 8½ in.).

A weekly report is required of each engineer. He makes this on a regular form, and it consists of brief statements of the operations of his corps during the calendar week, together with a summary.

The district advances to each resident engineer, when assigned, an amount equal to the approximate expense of maintaining his residency, pay roll excepted, during a month. At the end of the month each engineer is required to make out a complete statement of the expenses of his residency, detailing the same on a personal account form, and furnish receipts for each item of $1.00 or more. He is reimbursed for the amount of his monthly expenses during the life of the work or until he severs his connection with the district and then the amount of money advanced is deducted from that due him.



DIARY OF WORK PERFORMED.

[illegible] be filled in daily by the Engineer. The total days and the total amount distributed must correspond with pay roll for same period

Month of 191 Month of 191

DESCRIPTION | 1–31 | Tot. Days | Rate | Amount

Back of Pay Roll Sheet—Diary of Work Performed (13½ in. x 8½ in.).

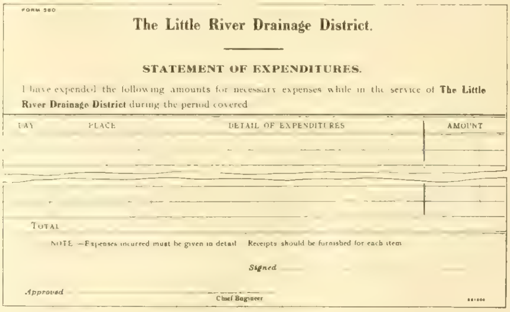
The pay roll form used is very similar to that used on railroads. The reverse side of the form is for the distribution of the time of the corps during the period covered by the pay roll.

A distribution of the various items appearing on the personal expense statements is also made and from these two, the pay roll and expense statement, a statement showing comparative costs is compiled. This statement also shows the costs on the basis of yardage handled each month and accumulated figures, as you will note.

Adequate excavation tables were not found in print, and it was therefore necessary that they be worked out by the chief engineer's office. The ditches range in base width from 4 feet to 123 feet and side slopes of 1 on 1 are specified. It was required to compile tables to fit each base width and to show the excavation quantity per station for each tenth of a foot between the minimum and maximum depths encountered. The second difference or the constant fractional change in quantity was found and tables of endings for the slopes specified were made out. These endings for 1 on 1 and 2 on 1 slopes are as follows:

Slope of 1 on 1.	Slope of 2 on 1.	Slope of 1 on 1.	Slope of 2 on 1.
.000	.000	.037	.074
.074	.148	.111	.222
.148	.296	.185	.370
.222	.444	.259	.519
.296	.592	.333	.667
.370	.741	.407	.815
.444	.889	.481	.963
.519	.037	.556	.111
.593	.185	.630	.259
.667	.333	.704	.407
.741	.481	.778	.556
.815	.630	.852	.704
.889	.778	.926	.852
.963	.926	.000	.000

In using the table of endings it is necessary to compute the quantity in yards in the prism at the minimum depth desired, then again compute the quantity in a prism greater in depth by one-tenth of a foot; deduct the lesser from the greater quantity and the fractional ending at the right of the decimal point will correspond to one of the endings tabulated. To produce a table of quantities is then but a matter of addition, using the next ending in order with the unit difference until from the table of differences it is apparent that the unit quantity must be increased by the addition of 1. For instance, a ditch prism of 4 ft. base, 1 on 1 side slopes and 5 ft. depth contains 166.666 cu. yd. per station. A prism of the same base width but 5.1 ft. in depth contains 171.888 cu. yd. per station. The difference in quantity for the change of one tenth in depth is 5.222 cu. yd. and the operation to produce a table of quantities for a ditch having a 4 ft. base would be as follows:



FORM 580

The Little River Drainage District.

STATEMENT OF EXPENDITURES.

I have expended the following amounts for necessary expenses while in the service of **The Little River Drainage District** during the period covered

DAY | PLACE | DETAIL OF EXPENDITURES | AMOUNT

TOTAL

NOTE.—Expenses incurred must be given in detail. Receipts should be furnished for each item.

Signed

Approved
Chief Engineer

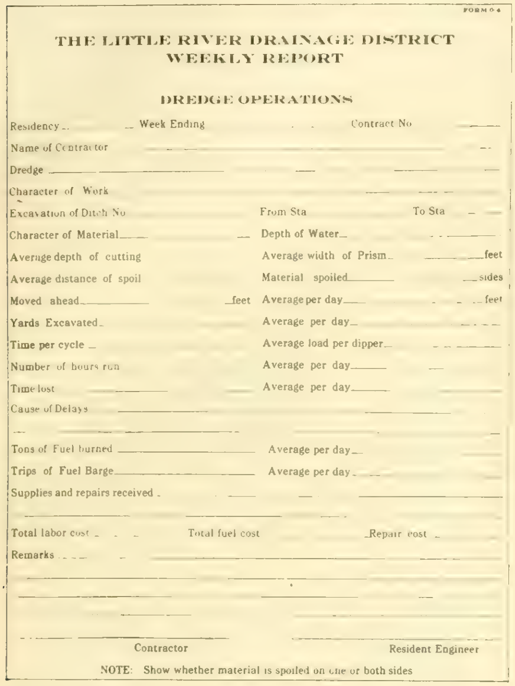
Statement of Expenditures (8½ in. x 11 in.).

Depth.	Quantity.
5 ft.	166.666 cu. yd.
	5.222
5.1 ft	171.888 cu. yd.
	5.296
5.2 ft	177.184 cu. yd.
	5.370
5.3 ft	182.554 cu. yd.
	5.444
5.3 ft.	187.998 cu. yd.

Following the above method and using an adding machine will enable any one to compile excavation tables of limitless range rapidly, accurately and with practically no mental effort.

All resident engineers chart the progress of the work under their supervision. On the diversion system line maps of large scale are used for recording all clearing estimates allowed and profiles, for recording the excavation. On the ditch construction blue print profiles are used to record all progress. Clearing progress is indicated by simply blocking out in black ink the range between which it is allowed and noting the month thereon. For excavation, conventional colors are used to outline the completed work during the month they are chosen to represent.

A photographic record is desirable on all work of any magnitude, and it is required that each resident engineer provide himself with a camera taking a picture not less than post card size. It is expected that at least three pictures will be taken to illustrate the work on each contract each month and sent to the chief engineer. Conditions are not always such that pictures can be taken and sometimes the number is not secured, and, again, when there is something the resident engineer wants to bring out especially, the number is exceeded. Quite a large album has been provided, and if it had not been a loose leaf book and capable of unlimited expansion, we might say that it was filled some time ago, but, nevertheless, the work is quite well and fully illustrated.



FORM O-4

THE LITTLE RIVER DRAINAGE DISTRICT
WEEKLY REPORT

DREDGE OPERATIONS

Residency ____ Week Ending ____ Contract No ____
Name of Contractor ____
Dredge ____
Character of Work ____
Excavation of Ditch No ____ From Sta ____ To Sta ____
Character of Material ____ Depth of Water ____
Average depth of cutting ____ Average width of Prism ____ feet
Average distance of spoil ____ Material spoiled ____ sides
Moved ahead ____ feet Average per day ____ feet
Yards Excavated ____ Average per day ____
Time per cycle ____ Average load per dipper ____
Number of hours run ____ Average per day ____
Time lost ____ Average per day ____
Cause of Delays ____
Tons of Fuel burned ____ Average per day ____
Trips of Fuel Barge ____ Average per day ____
Supplies and repairs received ____
Total labor cost ____ Total fuel cost ____ Repair cost ____
Remarks ____

Contractor
Resident Engineer

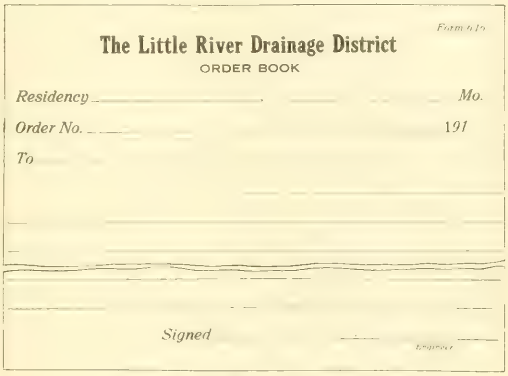
NOTE: Show whether material is spoiled on one or both sides

Weekly Report of Dredge Operations (8½ in. x 11 in.).

The field work of the supervising forces consists mainly of keeping the work staked ahead of the clearing and excavating operations; taking up the work completed, the clearing by inspection and the excavation by inspection and cross-sectioning the channels. It is the practice to make semi-monthly inspections of the work under construction. A description of the methods used in cross-sectioning is given in the Engineering & Contracting of Nov. 21, 1916.

Almost two years ago bi-monthly staff meetings were inaugurated. All of the resident engineers meet at the office of the chief engineer and discuss problems of common interest with which they meet during the progress of the work. At the initial meeting studies were outlined and committees appointed for the purpose of making the necessary investigations. These studies all have to do with drainage and canal construction and are as follows:

Deterioration of Ditches and Canals:—The purpose of investigating this subject is to determine, if possible, the most prevalent causes and suggest remedies.



Form 0-10

The Little River Drainage District
ORDER BOOK

Residency ____ *Mo.*
Order No. ____ 191
To ____

Signed ____
Engineer

Order Book Sheet (5¼ in. x 8½ in.).

Spoil Areas Required:—To ascertain by inspection the lines of repose of the various classes of soil and the areas that will be required for a given mass of spoil.

Excess Material Excavated:—To investigate the percentage of excess material excavated and the causes; also, to determine economical ditch sections for dredges of certain hull dimensions.

Right of Way Clearing:—To work out, if possible, a method of determining the necessary right of way for large canals to replace the rule of thumb that a right of way of twice the top width of the ditch plus the berm is required.

Protection of Banks:—To study the various types of protection for paving canal slopes and facing embankments and make such recommendations as seem justified considering economy and permanency of the protection.

TABLE I—THE LITTLE RIVER DRAINAGE DISTRICT DISTRIBUTION OF RESIDENCY EXPENSES FOR THE MONTH ENDING MAY 15, 1917.

Classification.	Residency 1.	Residency 2.	Residency 3.	Residency 4.	Residency 5.	Total.
PAY ROLL.						
Staking out work	$ 31.44	$107.20	$ 24.35	$ 37.70	$ 27.51	$ 228.20
Inspecting clearing	....	6.49	11.23	9.42		27.14
Cross sectioning	127.72	53.39	92.38	86.80	158.20	518.49
Office work	90.39	123.21	44.23	59.46	158.20	475.49
General inspection	178.92	377.71	42.69	28.26	13.76	641.34
Re-referencing	....	....	....	3.00	.....	3.00
Staff work	....	....	7.12	....	....	7.12
Miscellaneous	13.75	....	....	4.00	.	17.75
Land ties	....	....	....	....	.....	....
New line	68.78	....	.	15.86	.	84.64
Total	$511.00	$668.00	$222.00	$ 244.50	$357.67	$2,003.17
EXPENSE ACCOUNTS.						
Office expenses	$ 10.50	$ 1.15	$ 13.40	[illegible]	$ 15.44	$ 47.96
Lodging and sustenance	30.55	37.15	[illegible]	[illegible]	9.15	98.70
Transportation	71.97	77.71	[illegible]	[illegible]	41.01	218.04
Instruments and equipment	12.60	.....	.69	[illegible]	..	22.68
Miscellaneous	...	.....	....		....	....
Total	$125.62	$116.01	$ 53.50	$ 26.65	$ 65.60	$ 387.38
Totals	$636.62	$781.01	$275.50	$271.15	$423.27	[illegible]
Cu. yd. excavation	77,261	106,795	215,798	134,055	360,973	894,881
Supervision cost per cu. yd.	$0.00820	$0.00740	$0.00128	$0.00202	$0.00121	$0.00267
ACCUMULATION, 19 MONTHS						
Supervision cost	$8,881.15	$12,716.63	[illegible]	$6,558.73	$8,414.79	$42,145.90
Cu. yd. excavation	1,879,165	3,792,639	4,241,702	3,108,801	6,727,449	1,964,756
Cost per cu. yd.	$0.00472	$0.00335	[illegible]	$0.00212	$0.00132	$0.00217

Necessarily these studies had to be carried on at the leisure of the engineers and the investigations made at times when all routine matters were out of the way. Practically all of the committees have submitted their final reports, and some very interesting and valuable information has been gathered.

As stated in the beginning, the problem of proper distribution of drainage construction work and the size and composition of the corps to handle that work most efficiently and economically must be solved for each district, but, for this district, after a test of two years, the corps outlined and the routine methods described seem to be admirably adapted to the work and result in all matters being handled with dispatch and in the construction supervision being done very efficiently, at a minimum expense.

Mr. Wm. A. O'Brien, Cape Girardeau, Mo., is chief engineer of the district and Mr. Isham Randolph, Chicago, Ill., is consulting engineer.

WHEN TO DIMENSION IN FEET AND INCHES AND WHEN IN INCHES ALONE.

In a communication published in the May Journal of the Boston Society of Civil Engineers, Mr. Sturgis H. Thorndike of Fay, Spofford & Thorndike, Consulting Engineer, Boston, Mass., calls attention to the difficulty of making a standard rule which will determine when dimensions should be stated in feet and inches and when in inches only. In the hope of bringing out further discussion, Mr. Thorndike offered the following suggestions:

For use in engineering structures, the so-called English system of measures provides two units of lengths—the inch and the foot. The suggestion is that these be regarded as serving two distinctly different functions. The first unit is adapted to stating the width and thickness of any material or member which is constant in cross-section, but may have any convenient length; that is, the inch is the convenient unit in which to state size as distinct from length or distance. For instance, we habitually use the term 30-in. Bethlehem girder beam, 42-in. steel plate, 16-in. brick wall, 30-in. vitrified clay pipe, 38 in. by 50 in. egg-shaped sewer, 36-in. cast-iron water pipe, 12 in. by 16 in. yellow pine stick, 28-in. stone coping, 16-in. reinforced concrete slab, etc. We seem naturally to use the inch alone in these cases until the dimension exceeds 5 or 10 ft. On the other hand, we do not speak of a 720-in. roadway. I therefore believe that—perhaps subconsciously—we are using the inch as distinct from the foot and its subdivisions as the convenient unit in which to state the size of most materials and members.

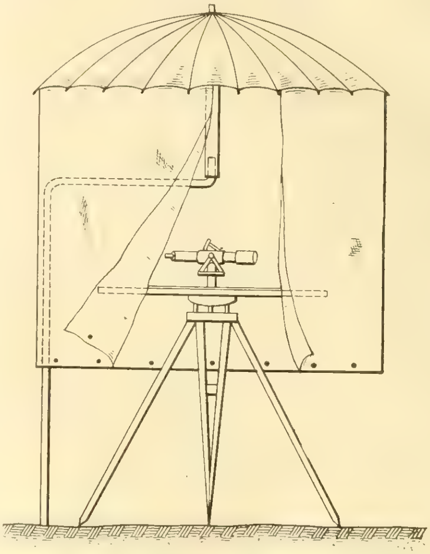
The convenient unit for length or distance seems to be almost always the foot. This unit may be divided decimally, but such division is outside the scope of this present discussion. If it is to be divided into inches, and especially if a number of lengths or distances may sooner or later need to be added together, the greatest convenience seems to be attained when the inch is regarded strictly as a subdivision of the foot, not as a different unit, and consequently when we state a length as 1 ft. 7 in., not as 19 in.

This recognition of the existence of two units, one adapted for one purpose and one for another, may clear up much of the confusion and solve most of the difficulties, including the dimensioning of plates. It sometimes results in stating the same dimension in two different ways on the same plan according to the purpose desired; for instance, the size of an I-beam may be 15 in., but the distance from a plate on the bottom of it to a plate on the top of it will be 1 ft. 3in. Whether this is an advantage or not is open to question; to me it seems an advantage as emphasizing the difference in use between the two units.

There will still remain a wide field for the exercise of discretion. The limit of size to be stated in inches seems to be a matter of judgment and convenience rather than rule. We speak of a 120-in. wheel base on an automobile, but of a 10-ft. sewer. There will also be differences of opinion on the distinction between size and distance; one engineer will mark his concrete column 28 in. by 32 in. for convenience in figuring stresses; another will mark it by 2 ft. 4 in. by 2 ft. 8 in., classing it as a mass of concrete.

WEATHER CLOTH FOR PLANE-TABLE UMBRELLA.

A weather cloth attachment for the plane-table umbrella, used in connection with work of the U. S. Coast and Geodetic Survey, has been designed recently by Mr. John W. Maupin of the Survey. In this attachment the cloth is fastened to the eyes of the outer ends of the umbrella ribs and extends all way around the umbrella with the exception of an opening which is left for light and taking sights. The usual sleeve is fitted to the shortened umbrella handle and this sleeve turns about the top of the L-shaped stanchion so the umbrella and cloth may be revolved and rod readings taken in any direction through the opening. The weather cloth may be folded up inside the umbrella when same is closed. It will probably be advisable to use weights to keep the cloth from blowing during windy weather.

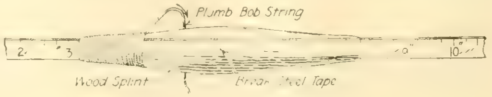


Weather Cloth Attachment for Plane-Table Umbrella.

FIELD MEND FOR STEEL TAPE.

A simple mend for steel tape is described by Mr. Hale H. Hunner in a recent issue of the Engineering and Mining Journal. The repair method is as follows:

When the tape breaks, cut a straight piece from a green alder or willow about 3 in. long. When the stick is split down the center and peeled, it should just cover the tape laid lengthwise. Smooth up the split faces and shave down the outside from the center of each half to a thin edge. About 3 ft. of plumb-bob string or stout cord will serve to wrap the splints. The cord should be wrapped as tight as possible each time and care taken to see that the binding does not have a chance to slacken up. When the splint is nearly half wound, place the broken ends together right side up and finish winding until the splint is entirely covered. A minute's soaking in water will remove any possibility of slipping. If it should slip at all, it will pull entirely out, thus there is very little chance of get-



Method of Mending Steel Tape.

ting wrong chainage. It slides through the brush and around rocks with very little hindrance and while it puts a stiff place in the tape, the advantage of a quick field repair overbalances the disadvantage.

METHOD OF MAKING DRAINAGE ASSESSMENTS.

A system of spreading drainage assessments that has the advantages of assessing direct benefits as well as general benefit, is described by V. R. Ewing in the March Iowa Engineer, from which the following notes are taken.

The land within the district is classified into four divisions as regards its value to the farmer: slough land, wet land, low land and dry land. Land upon which a crop can be grown only in exceptionally dry years is slough land; upon which a crop can be cultivated and grown about 40 per cent of the time is wet land; upon which a crop can be cultivated and grown about 70 per cent of the time is low land; and land upon which crops can be raised practically every year, but which, nevertheless, is subjected to the general benefit derived by all the land within the district, is dry land.

The board of appraisal, or assessment committee, goes over the land carefully, and from the appearance of the land and the state of the crops upon it, determine, for each 40-acre tract, the number of acres coming under each one of the above divisions. The sum of these acres must equal 40 acres because in this system no land in the district is entirely exempt from assessment.

The first step for the engineer in figuring the assessments, after the work of the assessment committee is finished, is to compute the direct benefit derived by each section of land, as set down in column 8 in Table I. The direct benefit is the benefit derived from the land through which the tile lines of the district actually pass, and is computed in the following manner. Suppose that, in the design of the system, an 18-in. tile goes through a 40-acre field. Evidently this land will receive some direct benefit from this line not received by land farther removed from it. The engineer, after looking over this tract of land, decides that, if the farmer were to place a tile line through the land and along the line that the district line follows, an 8-in. tile would have sufficient capacity to drain the area. Therefore, the owner of the land should pay for the cost of an 8-in. tile of the same length as the district line through his land, and the district should pay the difference in cost between an 8-in. and an 18-in. line. If the length of the line through the land in question was 1,200 ft., as scaled from the map of the district, and the cost of an 8-in. tile of necessary depth was $8.00 per station, the direct benefit assessment for this 40-acre tract would be 12.00×$8.00 or $96.00. The length of each tile line in stations for each tract of land is set down in column 6 and the value per station in column 7 (see Table I). In a similar manner the direct benefits are computed for all the land through which the district tile are placed. The total amount of direct benefits, as computed from column 8, is subtracted from the total cost of the improvement, including damages, engineering, etc., and the difference is the amount to be raised by the other assessments.

TABLE I

Name.	Land Description.	Equiv. Slough Acres.	Factor	Benefit	Tile line in Sta.	Value per Station	Direct Benefit	Total Benefit
A. Jones	NE¼NW¼	5.00	20.482	$102.41	12	$8.00	$96.00	$198.41
J. Doe	SE¼NW¼	21.72	20.482	444.8				444.87

The next step is the reduction of all acreage within the area to an equivalent slough acreage basis by a method of proportioning the per cent of improvement of each one of the four divisions of land previously mentioned. In this proportion, slough land is considered 100 per cent benefited, wet land as 60 per cent, low land as 30 per cent and dry land as 3 per cent. Take for example the forty acres listed in the second line of the table. The assessment committee decided that this tract consisted of 9 acres of slough land, 15 acres of wet land, 12 acres of low land and 4 acres of dry land. In order to reduce this to equivalent slough acres, the following computations are necessary:

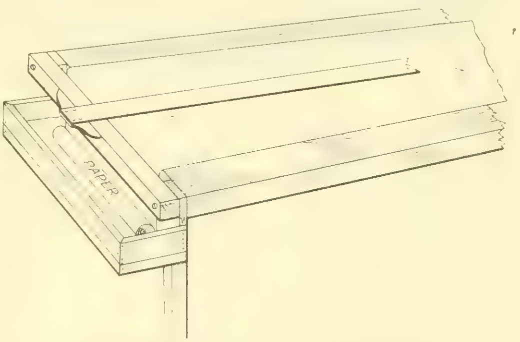
9 A. slough land	x	100%	equals	9	A. equivalent slough acres.
15 A. wet land	x	60%	equals	9	A. equivalent slough acres.
12 A. low land	x	30%	equals	3.6	A. equivalent slough acres.
4 A. dry land	x	3%	equals	.12	A. equivalent slough acres.
40 A.			Total	21.72	A.

By proceeding in this manner, with all of the land assessed and totalling the amounts in column 3, the total slough acreage of the district is found. If the total cost of the improvement, less the total direct benefit, is divided by the total slough acreage, the factor of column 4 is obtained. The product of columns 3 and 4 gives the general benefit derived for each forty-acre tract within the district, as set down in column 5. The product of columns 6 and 7 gives the direct benefit received by each tract as shown in column 8, and the sum of columns 5 and 8 gives the amount in column 9, the total assessment for each tract of land within the range of the improvement.

The advantages of this system of assessment lies in the fact that direct benefits as well as general benefits are assessed; and by this system of computing, the total benefit and total cost are bound to check, unless some mistake has been made in computation.

ATTACHMENT TO FACILITATE HANDLING LARGE DRAWINGS.

A convenient arrangement for handling tracings longer than the drawing board is illustrated below. Blocks are fastened to the end of the board and a strip of wood screwed to the blocks, thus forming a slot through which the tracing cloth is passed. The roll rests upon a shelf attached to the board as indicated.



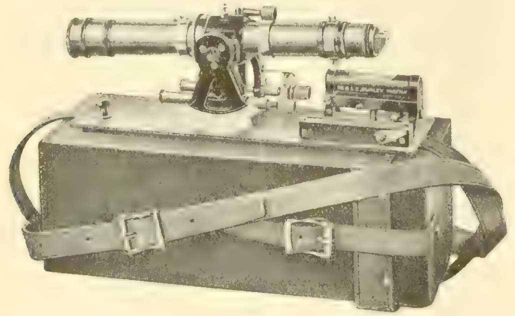
Arrangement for Handling Large Tracings.

MEASUREMENT OF PRECISE LEVELING RODS OF U. S. COAST AND GEODETIC SURVEY.

The rods used by the U. S. Coast and Geodetic Survey in its precise leveling work are now measured accurately, at frequent intervals, in the field and the resulting lengths are used in the office computation of the lines. The lengths of the meter intervals are transferred by means of a beam compass to a standard meter bar. Three such transfers of each meter space constitute one measurement. The standard meter bar is a strip of invar metal 7 millimeters wide by 0.5 millimeter thick and a little more than 1 meter long, having near one end of it a small conical hole and about 1 meter from it, at the other end of the bar, a series of fine-line graduations. To protect it from injury the entire strip is set into a dovetailed groove in a brass bar 1 in. wide by ¼ in. thick and about 3½ ft. long. The invar strip is fastened to the brass bar at only one end so as to allow free longitudinal expansion. Standard meter bar No. 2 was used. This bar has a length of 0.999984 meter at 0° C., and has a temperature coefficient of 0.0000004 per degree centigrade. The results of the field measurements show that the rods decreased in length in proportion to the length of time they were used. Formerly the rods were measured by the instrument division of the survey at the beginning and the end of the work. The behavior of the rods during the season was watched by means of a steel tape especially designed for that purpose. The measurements in the field were sufficiently exact to indicate whether the rods maintained their lengths or actually changed and the amount of the change, if any. If the length of the rods underwent only small changes, a mean length of the rods for the season was adopted from the office measurements.

LIGHT WEIGHT EXPLORERS ALIDADE.

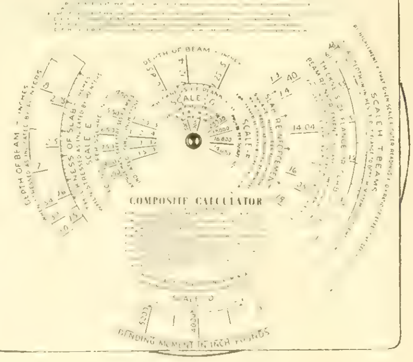
A new model light weight alidade has been brought out recently by W. & L. E. Gurley, Troy, N. Y. This instrument is a modification of the well-known No. 584 Gurley alidade, U. S. Geological Survey pattern. It is smaller and lighter than the older instrument and has several special features. Among them is the elbow eyepiece, which relieves the fatigue and inconvenience experienced in observing with the average type of eyepiece. The range of the instrument is considerably increased. A depression of 25°, or an elevation of 30° may be read with the greatest ease. The alidade weighs 3¼ lb.; the weight including leather-covered case, 3½ in. by 3¾ in. by 10½ in., with shoulder sling, is 5 lb. The instrument also has the Beaman stadia arc, which does away with the use of tables, slide rules or diagrams in the reduction of stadia readings, and gives accuracy and speed to stadia surveying.



New Gurley Model Light Weight Alidade.

COMPOSITE CALCULATOR.

A composite calculator for use in designing reinforced concrete slabs, beams and girders has been place on the market recently by Kolesch & Co., New York City. By means of the calculator the following results can be obtained: Size of reinforced concrete plain and tee-beams; thickness of reinforced concrete slabs; reinforcement for plain and tee-shaped concrete beams; reinforcement for concrete slabs; size of wooden beams and thickness of various kinds of wooden planks and board. The device also can be used for various other purposes such as checking safe load, comparing relative sizes of beams, multiplying and dividing, etc. The computations for concrete are based upon the Joint Committee recommendations, using the straight line formula.



Composite Calculator.

PERSONALS.

Ira R. Browning has been appointed State Road Engineer of Utah, succeeding E. R. Morgan.

Alexander Allaire has been elected Vice-President of Fraser, Brace & Co., contractors, New York City.

J. E. Bernhardt has been appointed bridge engineer of the Chicago & Eastern Illinois R. R., with headquarters at Chicago.

O. E. Noble has been appointed highway engineer of Riley County, Kansas. Mr. Noble formerly was city engineer of Manhattan, Kan.

W. W. Kelly has been appointed Division Engineer of the Albuquerque Division of the Santa Fe System, succeeding M. C. Bryan, transferred.

Lieut. Col. William J. Barden, U. S. Corps of Engineers, has been relieved from duty at Dallas, Texas, and assigned to the Fifth Regiment of Engineers.

E. J. Carrell, heretofore district engineer of maintenance of way of the Southwest district of the Baltimore & Ohio R. R., has been appointed Superintendent of the Delphos Division.

Hunley Abbott has resigned as vice-president and chief engineer of the MacArthur Concrete Pile and Foundation Co., to accept a position with the Bartlett Hayward Co., Baltimore, Md.

H. B. Wells has been appointed assistant superintendent of construction for the Matanuska District of the Alaskan Engineering Commission now engaged in the building of the railways in Alaska.

Frederick McQ. Falck has been appointed Assistant General Manager of the Philadelphia & Reading Ry., with headquarters at Reading, Pa. Mr. Falck entered railway service as assistant supervisor, becoming later division engineer and then assistant superintendent.

Daniel T. Pierce, of the staff of the Barber Asphalt Paving Co., has been appointed executive director of the Committee of Public Safety for the Commonwealth of Pennsylvania. The appointment was announced at a conference in the Governor's office at Harrisburg this week.

William H. Connell, for five years chief of the Bureau of Highways of the Department of Public Works of Philadelphia, Pa., has resigned that position and on June 1 becomes engineering executive for the firm of Day & Zimmerman, Consulting, Constructing and Operating Engineers, Philadelphia.

A. L. Grandy, since 1913 chief engineer of the Pere Marquette R. R., has been appointed assistant general manager with headquarters at Detroit, Mich. Job Tuthill, heretofore of the engineering department of the Michigan Central R. R., succeeds Mr. Grandy as Chief Engineer of the Pere Marquette.

Geo. W. Arnold, Construction Engineer, Baltimore Peach Bottom Slate Corporation, Delta, Pa., has been appointed manager, and will assume the duties of Capt. Carl R. Gray, Jr., president of the company, who has been called to the colors as Assistant to Department Quartermaster, Charleston, S. C.

Robert C. Terrell, former Commissioner of Public Roads of Kentucky, who has been connected with the Department of Civil Engineering at the University of Oklahoma, at Norman, has been promoted to the rank of Associate Professor in charge of the new department of Highway Engineering, which is to be a branch of the school of Civil Engineering in the College of Engineering at the University.

Changes in the engineering department of the Atchison, Topeka & Santa Fe Ry. have been announced as follows: R. N. Priest, construction engineer, appointed division engineer at Kansas City, Kan., succeeding H. J. Moore. L. G. Harris, acting division engineer at La Junta, Colo., appointed division engineer at that point, succeeding Claude Betson. L. M. Townsend, acting division engineer at Dodge City, Kan., appointed division engineer, with same headquarters, to succeed L. C. Graves. Irving Anderson, office engineer at Chicago, appointed acting division engineer at Marceline, Mo., succeeding W. C. Baisinger.

F. L. Beal, heretofore superintendent of the Louisiana & Arkansas R. R., has been appointed chief engineer. Mr. Beal is a graduate of the civil engineering department of Purdue University. He entered railway service with the Cleveland, Cincinnati, Chicago & St. Louis Ry. as an instrument man, and in August, 1909, was employed by the Louisiana & Arkansas as a transit man, since which time he has been consecutively assistant engineer maintenance of way, resident engineer, chief clerk to the general superintendent, chief clerk to the general manager, valuation engineer, statistician in charge of rate cases and superintendent.

The American Electric Railway Association's committee on national defense consists of: Chairman, Gen. George H. Harries, Omaha, Nebr.; vice chairman, Frank R. Ford, 115 Broadway, New York, N. Y. (in charge of general matters); L. S. Storrs, New Haven, Conn., assigned to the Northeastern Military Department; B. I. Budd, Chicago, Ill., assigned to the Central Military Department; C. Loomis Allen, Syracuse, N. Y., assigned to the Eastern Military Department; P. H. Gadsden, Charleston, S. C., assigned to the Southeastern Military Department; L. C. Bradley, Houston, Tex., assigned to Southern Military Department; W. R. Alberger, San Francisco, Cal., assigned to the Western Military Department.

INDUSTRIAL NOTES.

E. C. Bauer has been appointed assistant to the vice-president of the American Manganese Steel Co., Chicago.

John W. Dix, assistant general manager of sales and structural engineer for the Carnegie Steel Co., died last month at Atlantic City, N. J., aged 43 years.

The Steel-Lock Concrete Construction Co., Pittsburgh, Pa., has established western headquarters in the New York Bldg., Seattle, Wash., with Martin Kostad in charge.

George W. Neff, formerly with the Platt Iron Works Co., has been appointed New York representative of John H. McGowan Co., manufacturers of pumping engines, with offices at Room 1567, 50 Church St., New York.

Road and Street Issue
of

Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

First Wednesday Each Month............Roads and Streets......$1 Yearly
Second Wednesday Each Month, Waterworks and Hydraulics.......$1 Yearly
Third Wednesday Each Month....Dirt Mover and Pit Owner......$1 Yearly
Fourth Wednesday Each Month.....Buildings and Structures.....$1 Yearly
Fifth Wednesday.......Planning and Management Quarterly...25 cts. Yearly
Every Wednesday...$3 Yearly
Any Two or More Monthly Issues, 75 Cents Each Per Year
Contract News Appears in All Issues

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WHY NOT ORGANIZE A NATIONAL ASSOCIATION FOR BETTER STREETS?

The various "associations for better roads" have been so effective in arousing public interest in country roads that it seems feasible to secure better city streets through the activity of similar associations. Certainly there is need for educational propaganda for better streets, and particularly for better laws under which to secure street improvement.

As long as country roads were built entirely from funds raised solely by taxation on the property along and adjacent to the roads, there was no marked progress in road improvement. The reasons for this are obvious. A comparatively heavy tax on property that is directly benefited by a road comes so far in advance of the full benefit that relatively few farmers can be made to see that the investment will be a good one. Furthermore, they can see that the entire community derives a benefit from every good road, and that this general benefit is frequently of greater magnitude than the benefit to the farmer who is taxed to provide it. Precisely the same condition exists as to city streets, and the general benefit from street improvement is even more marked than from road improvement. Moreover the greater portion of city property is leased and the landlords feel that while street improvement will increase their tax payments it will not correspondingly increase their revenue. Hence the majority of city property owners are apathetic, or worse, when any proposal is made to improve the pavements.

If there were a national better streets association, with local chapters in every one of the 12,000 municipalities, working for better laws relating to assessments for street construction and maintenance there would assuredly come rapid improvement in city thoroughfares. Who will deny that improvement is sorely needed?

Kansas City has built more than 100 miles of handsome boulevards over which it is a delight to travel. This boulevard system is justly "the pride of the city." Its use is restricted to pleasure vehicles. Beautiful residences adorn many miles of these boulevards, and on holidays thousands of motor cars speed along this fine highway system. Such a highway could never have been built from money raised solely by assessment on abutting property. It stands as a great object lesson, showing what can be accomplished when the entire city joins in a movement to build fine roadways within its limits.

With an object lesson like this before them, why do the citizens of Kansas City permit most of their remaining streets to be anything but creditable? The answer is found primarily in the system of taxation for street improvement. Suppose, now, a better streets association were to be organized in Kansas City having as its first object the changing of existing methods of assessing street improvement taxes. Suppose its next move were to secure the construction of a commercial street system, corresponding to the existing pleasure boulevard system. Suppose this commercial street system were designed primarily to facilitate the delivery of goods from the stores in the business section to residences. Suppose it were planned to build this main delivery highway system first, and then to follow with a comprehensive plan of improving the streets that feed into it. Can it be doubted that such a program would receive the widest publicity in the daily papers of Kansas City? Or that it would rapidly win adherents?

The organization of better streets associations might be undertaken by the engineers' clubs of our larger cities. In fact, we suggest that the Engineers' Club of Kansas City may well lead this movement, since their city already has a boulevard system that serves to show how much better it is to undertake highway improvement as a civic duty rather than leave it to the disconnected efforts of individual taxpayers.

PRESERVE YOUR "SENSE OF PROPORTION" WHEN CONSIDERING THE EFFECT OF WAR.

Speak in billions if you wish to paralyze the brain accustomed to think in thousands. And if you would preserve your own "sense of proportion" do not allow your mind to be influenced by large figures until you have placed them in their appropriate setting of larger figures.

The "Liberty bonds" will total two billion dollars, a hugh sum until you place it alongside of a huger one—our total national wealth which is a hundred times greater. A war tax of $1,500,000,000 is a big sum, but it is less than 3 per cent of our aggregate annual income. A million men taken from work and sent to war is an army of great size, but it is only 4 per cent of our male population that is old enough to earn a livelihood.

"Girard" remarks in the Philadelphia Ledger that our foreign trade balance for one week will pay all interest on the Liberty Loan for a year, and that if each individual in America would now contribute 75 cents the year's interest could be paid in advance.

Paralyzed by huge totals even our business men have not always kept their "sense of proportion." Some of them have acted as if almost the entire populace were about to enter the trenches, forgetting that even in sorely tried France only one man in six is a soldier, and in England only one in twelve. In America the ratio will probably be about one in twenty.

Sir George Paish, the celebrated English statistician and economist, says in "System" for June:

> War means trade activity, not depression. * * * The immediate effect of the declaration of war upon American trade and prosperity will be beneficial, for money will circulate as never before.

He predicts a business activity in this country much greater than during the months preceding our entry into the war and that the only limit will be the limit of our productive capacity after calling all available women into our industries. Incidentally he indicates how the food problem may be solved:

> In periods of financial crisis in the past the American people have reduced their food consumption about twenty per cent. If they will do this now, they will set free for the purpose of supporting life in other countries upwards of 100,000,000 bushels of wheat and a vast quantity of other foods in the course of a year.

If 5 per cent of our men of fighting age go to the front, and if another 5 per cent are required to keep them equipped and fit, the total decrease of 10 per cent will be fully offset by increased productiveness of the 90 per cent left behind, to say nothing of women who will enter the industrial ranks.

Let us, by all means, regain our "sense of proportion" if we have lost it as a result of reading about millions and billions. Some of us have made a rather sorry spectacle these past two months hobbling about with feet cold enough to refrigerate a brewery.

WHY HIGHWAY CONSTRUCTION SHOULD BE INCREASED IN WAR TIME.

During the first hysteria begotten by our entrance into the world war a governor of one of our central states issued a statement that highway work should be curtailed during the war, in order to economize. At the very time that true economy is called for, this governor proposes to call a halt on a class of construction whose primary aim is to reduce the cost of transportation and insure the prompt delivery of perishable farm products.

Fortunately few men in high office have such nearsighted vision. Whether this war is to last one year or five, there is abundant economic reason for opposing any curtailment of the program for building improved roads and streets. If the war is to be short, then the slight temporary saving of capital effected by discontinuing highway work will be negligible. If the war is to be long, then we shall secure the greatest economy by the building of even more good highways than are now planned.

Horses for farm work are already scarce and a long war will make them scarcer. With better roads and streets it becomes possible to release many horses for plowing, cultivating and harvesting, because motor vehicles far excel horses wherever pavements are good.

One motor car factory is said to have a capacity of nearly a million 25-horsepower cars a year. Where is there a horse or mule factory capable of such a power output? The hauling power of 25,000,000 horses can be created every year by this one factory, but the ability to use this vast power every day of the year depends entirely upon the existence of hard, smooth roadways.

We need a campaign for better streets as well as better roads, as we have indicated in another editorial article, and we need it right now. The paving of streets will not only release more delivery wagon horses for the farms but will reduce the cost of delivery in the cities, thus effecting a double economy.

The American Society of Civil Engineers would perform a great and urgent service were it to take action now toward the encouragement of a great highway building campaign during the war.

12,000 AMERICAN MUNICIPALITIES THAT NEED MORE ENGINEERS.

Prof. Arthur H. Blanchard of Columbia University recently said:

> There are over 3,000 counties in the various states. The county and township highway work is in the hands of 100,000 highway officials. The 12,000 municipalities in the United States each have from 1 to 20 officials in charge of departments whose work pertains to highways.

These statistics were given to indicate, in a general way, the latent opportunities that present themselves to civil engineers in the highway field. But our present object in quoting these figures is to draw particular attention to the large number of municipalities and to suggest to engineers some of the varied openings that are offered to men of technical and executive training.

In our last issue attention was again drawn to the increasing number of civil engineers who are securing positions as city managers. Although we have barely made a start along this line of executive engineering, it is patent that the public is in a mood for a change from oldtime political to new-time engineering management of city affairs. Most of our 12,000 American municipalities will respond to the active efforts of civil engineers who seek to show them how to secure better administration of their streets, sewers, water works, fire departments, public buildings, etc.

In the smallest municipalities one or two engineers could not only effectively attend to all the executive work but direct all the engineering work and, in fact, themselves solve nearly all the engineering problems. Indeed if there were a more general disposition to call in consulting engineers and contractors, a single engineer-manager could not only effectively manage all the affairs of fair sized municipality but superintend its ordinary construction and maintenance work.

It is probably not overstating matters to say that fully 50,000 civil engineers are needed, and badly needed, to manage municipalities and design and supervise city work in America. How shall we organize ourselves to bring the public to a realization of this need? Last week we published an answer that the Cleveland Engineering Society has given to this question. We shall welcome any suggestions from our readers.

A SOCIETY THAT HAS CHANGED ITS ANNUAL MEETING PLACE AND PROGRAM ON ACCOUNT OF WAR.

The Society for the Promotion of Engineering Education has decided not to abandon its annual meeting but to hold the meeting in Washington, D. C., July 6-7, in connection with the educational committee of the Advisory Commission of the Council of National Defense. News of this change reached us subsequent to the writing of the editorial on the abandonment of the annual meeting of the American Society of Civil Engineers.

The major topic of discussion before the S. P. E. E. is to be "The Relation of the Engineering Schools to the National Government During the Present Emergency." There is abundant opportunity to perform not merely a temporary but a lasting service to the nation through the maturing of plans whereby all engineering students may secure some training in military engineering, in hygiene and in muscular strength. Let more of the West Point system be introduced into all our engineering colleges. It will make our engineers better fitted to command, better physically, better in appearance—better engineers and better leaders.

ADVERTISING FOR A CITY MANAGER.

A city of 11,000 population is advertising for a city manager whose "salary will probably range from $200 to $250 per month." The salary is small for such a responsible position in a city of this size, but doubtless many engineers will apply for the position in the belief that through efficient management they can demonstrate that they are worth a considerably higher salary.

The city is Goldsboro, N. C., and applications will be received until July 1. The advertisement states:

> Applicant must have pleasing personality, good business judgment and broad vision. One possessing qualifications of Sanitary Engineer preferred, though this is not absolutely essential. Excellent opportunity for energetic man of ability to produce results. City Manager Committee, P. O. Box 461, Goldsboro, N. C.

This is a pioneer advertisement of its class, but doubtless the precedent thus established will be followed by many another American city.

ANNUAL CONVENTION OF THE AM. SOC. C. E. ABANDONED.

The annual convention of the American Society of Civil Engineers, which was to have been held next week in Minneapolis and St. Paul, has been abandoned. It was decided that the existence of the war would so greatly reduce the attendance at the convention that no attempt should be made to hold it. Also it was known that several other societies have taken similar action for similar reasons.

Question naturally arises as to the wisdom of completely abandoning an annual convention of any great national engineering society. Surely the percentage of members who have been already "called to colors" can not be great enough to justify such a step. There is, it is true, a tendency among engineers as among other thinking men, to "mark time" at present. But, even granting that this feeling would keep many civil engineers from going to "The Twin Cities," was it wise to give up the annual meeting entirely? Might it not be wiser, even now, to postpone the meeting till fall? In the interim could not the program be changed so as to provide for the presentation of papers relating to the work that civil engineers will perform in war?

LETTERS "TO THE EDITOR" REQUESTED.

Letters "to the editor" of a periodical are really letters to the fellow-readers of the periodicals, and the editor is merely the go-between. His function is primarily to decide the worth-whileness of the communications thus transmitted. If he exercises this function wisely the editor adopts a very liberal policy as to what is a "worth-while" letter. One of our readers writes:

> We American engineers need a little space in some leading technical periodical in which to address our brother engineers, or at least occasionally a few of them. Some of the other papers rather frown upon this kind of thing, and do not give space to letters of the kind mentioned.

This reader undoubtedly voices the feeling of many others. He and all others are assured that we gladly welcome their letters, nor need the subject matter always be purely technical. Letters relating to public affairs will be gladly received, for we believe it to be a part of every engineer's duty to aid in the solution of civic problems. Among all classes of engineers the civil engineer seems to us to be particularly charged with the duty of forming and guiding public opinion. Let us begin with discussions in the form of published letters to one another, and thence advance to organized action whereby the general public may be educated to a better appreciation of the nature of economic problems and how to attack them.

WARREN PATENT DECISION.

To the Editor: A suit entitled Warren Brothers Co. vs. N. C. Evans, for the threatened infringement of the Warren basic patent, under which the bitulithic pavement is laid, was recently before the Circuit Court of Appeals for the Fourth Circuit sitting in Philadelphia, wherein both the validity of the patent was attacked, and its threatened infringement denied.

Judge Buffington, in delivering the opinion of the court, stated: "This patent has been considered by various Federal courts and its validity established," and also that "The present case turns on the question of infringement."

The specifications under which the contract in suit was awarded, which it was claimed would necessarily require the construction of a pavement infringing the claims of the Warren basic patent, provided for the use of "Bitumen"; "Limestone dust or Portland Cement"; "Stone: ¾-in. hard crushed"; and "Sand: coarse to fine."

The court held that under these specifications the contractor was called upon to use stone of one grade only, viz., ¾-in. stone, "Which was not the run of the crusher," and that this was not the composition called for by the specifications and claims of the Warren patent.

After considering the several claims of the patent sued upon, all of which require the use of a graded mineral aggregate, and after referring to the several cases of Warren Brothers Co. vs. Owosso, 166 Fed. Rep. 309; Warren Brothers Co. vs. Grand Rapids, 216 Fed. Rep. 231, in all of which cases the validity of the patent in suit was sustained and injunctions issued to restrain its threatened infringement where the pavement had not already been laid before suit was commenced, the court pointed out that in the New York case the mineral aggregate "was the resultant run of the crusher, which would necessarily have smaller grades of stone." The court summarized its conclusion by saying: "It will thus be seen that in all these cases there was a series of graded stones. In the present case there is but a single grade of stone, namely, that which will pass through a ¾-in. mesh and that which is caught on a ½-in. mesh."

As neither "run of the crusher" nor different sizes of stone were required to be used, the court said there could be no infringement in this case, and the suit was accordingly dismissed.

This decision raises the following questions:

1. The practicability of actually furnishing a stone in large commercial quantities of the uniform size which the court construes to be required by the specifications referred to, to-wit: Stone all of which "passes through a ¾-in. mesh and that which is caught on a ½-in. mesh." Certainly no such finely screened, uniformly sized product has ever been furnished by any crushing plant operating along commercial lines. Furthermore, stone about 1-in. size; that is, passing a 1¼-in. screen and retained on ordinary dust jackets in the crusher plant, is the size of stone most generally in demand for most purposes such as building construction, sidewalks, etc. The use exclusively of the intermediate portion ("which will pass a ¾-in. mesh and that which is caught on a ½-in. mesh" as defined by the court to be "¾-in. stone") of this ordinary crusher product in the quantities required for the wearing surfaces of a street pavement would evidently very greatly increase the cost of stone, and doubtless most stone producers would not agree to furnish stone of this limited size.

More particularly, approximately 50 per cent of the ordinary stone crusher product is of 1 in. and finer sizes. Of this total of 50 per cent finer than 1 in., approximately 50 per cent; that is, 25 per cent of the entire crusher product, is coarser than ¼-in. size. Of this 25 per cent, only 40 per cent or a total of 10 per cent of the product of the crusher, is of the uniform size which the court in this case decides is described by the specifications in suit, to-wit: that which "will pass a ¾-in. mesh and that which is retained on a ½-in. mesh." In other words, to comply with such specifications a contractor can use only 10 per cent of the product of his crusher or from the crusher from which he purchases his supply, and other disposition must be made of the other 90 per cent. For instance, given a paving contract to be laid at the rate of 1,000 sq. yd., requiring 75 cu. yd. of crushed stone per day, and a crusher plant having a rated capacity of 150 cu. yd. per day, that crusher would only furnish 15 cu. yd. per day or one-fifth of the daily requirements of stone for such a paving contract. In other words, it would take five such crushing plants to keep the paving plant in operation, and the person supplying the stone would have to find another market for 90 per cent of the product of his crushers. Aside from this, the production of such a stone would require additional intermediate separating screen and bin facilities, which are not commercially used, and which could be installed only at great expense and inconvenience. In other words, the court has excluded from the scope of the patent in suit the use of a stone which has never been practically produced, and cannot be produced without such increased expense and inconvenience that at least most owners of crushing plants would not undertake to do so, and then, under that extreme construction of the specifications says that Warren's basic patent No. 727,505, would not be infringed.

It is a self-evident fact that neither as high degree of stability nor freedom from voids can be produced by a mineral aggregate consisting of such a uniform sized stone and sand as is produced by the construction generally adopted, in which various sizes of crushed stone or gravel, sand and pulverized stone are used in such definite proportions as will produce the highest degree of stability, freedom from voids and utility.

3. Even though such a construction, using uniform sized stone (passing ¾-in. and retained on ½-in. screen) and sand be held to come outside of the Warren Basic Patent No. 727,505, it is very clearly directly in the teeth of the Warren Patent No. 695,421, the single, very clear claim of which is as follows:

> A wearing layer of a street sheet pavement composed of a dense mineral body consisting only of relatively large elements, one-half inch and upward in diameter, and relatively small elements, one-tenth of an inch in diameter and less, having predetermined proportions and intimately and uniformly associated throughout the body to eliminate voids, provide stability and a wearing surface and a uniting weather-proof, bituminous vehicle intimately associated with all the mineral elements serving to combine and unite them, fill the voids remaining unfilled and to form with the mineral body a solid, stable, homogeneous, tenacious, elastic, bituminous wearing layer.

As far as we know, this patent, No. 695,421, has never been infringed in any actual construction.

Warren Brothers Co.,
Geo. C. Warren, President.

Boston, Mass.

METHOD OF RESURFACING OLD MACADAM ROAD.

Contributed by Chas. R. Thomas, Assistant Engineer, Construction Service Co., New York.

A macadam road begins to wear as soon as completed. As the road wears opportunity is afforded to observe the weak points. Sometimes faulty construction methods cause undue wear. All little faults should be corrected as soon as possible by maintenance. Ordinary maintenance is largely a matter of road nursing, nursing to keep the surface smooth until it becomes so badly worn that it is economical to replace it. If this nursing is begun as soon as the road is completed the life of the surface will be considerably prolonged.

There are a number of rules for approximating the economic life of a macadam road. As a rough estimate, it may be said that a road should be resurfaced when the annual cost of maintenance obtained by totaling the repairs over the whole period and dividing by the life exceeds the yearly cost of resurfacing. For example: If it costs $1,800 to resurface a mile of road, the yearly cost of resurfacing at the end of 6 years would be $300 a mile a year. If at the end of 6 years the total repairs divided by 6 is over $300 a mile a year, the road should be resurfaced. So when ordinary maintenance becomes uneconomical resurfacing work should begin.

Types of Resurfacing.

Macadam resurfacing problems usually encountered may generally be divided into three classes:

(1) Extraordinary repairs, such as scarifying and compacting an old road without the addition of new macadam.

(2) Resurfacing, including all work replacing the old road surface.

(3) Reconstruction, including relocation, regrading, safer bridges and culverts, and changes in the width and type of surface.

Extraordinary Repairs.

Extraordinary repairs are desirable when a road has become pitted or rutted so as to present a rough and unsatisfactory surface for travel, but there remains on the road a sufficient quantity of stone to make a satisfactory thickness without the addition of new material. Such a condition frequently results from the use of crusher-run stone on a road having heavy automobile traffic. A patch of fine stone in the surface will wear more rapidly than the rest of the surface and generally results in a pothole. Also crusher tailings of large size wear slowly and make a bumpy road. On narrow macadam roads where travel is necessarily confined to one track, two and sometimes three well defined ruts generally appear. When these ruts exceed a depth of 2 in. scarifying is desirable.

Before scarifying all accumulations of mud and dirt should be scraped from the roadway, ditches cleaned with the road-machine and the shoulders trimmed of sod along the edges of the macadam. But if the ditches drain well and the shoulders are well sodded do not disturb the sod except the narrow strip along each edge of the macadam which it is usually desirable to remove.

As a rule, do not scarify deeper than necessary to secure sufficient material to restore the shape of the road, and never so deep that there does not remain about 4 in. of unloosened stone above the subgrade. If only 4 in. of macadam exists do not scarify at all; the road needs resurfacing, and scarifying and shaping will decrease the supporting strength of the old macadam.

In scarifying the roller should be run straight, otherwise short unscarified places will be left in the road. I have found it a good plan to begin scarifying along one edge and ink lapping over to let one scarifier tooth lap onto the scarified area. It is frequently necessary to go over the same area twice, and in this case I generally remove alternate teeth in the scarifier for the first scarifying and replace them for the second scarifying. Finally, when having scarifier teeth sharpened take them to a good blacksmith, and always have an extra set with the scarifier.

In shaping a skillful grader operator can fill all holes and depressions for some distance along the road by keeping the blade almost square with the road. Fresh screenings should always be used to rebond the road. The quantity necessary, however, is considerably less than required for new work.

Repairing holes and ruts without the use of a scarifier calls for considerable skill and, above all things, the proper sizes of stone. In this work a roller is desirable, but satisfactory work may be accomplished without a roller if the repairs are made in wet weather. For deep holes large stone should be used in the bottom and intermediate size (1-1¾ in.) on top with a good dressing of screenings. Use the intermediate stone for shallow holes, and do not leave the patch very high. The most satisfactory size of stone for patching work varies with the quality of the stone and the type of traffic on the road, and a little observation is worth much. The spring is usually the best season of the year for repair work without a roller.

Resurfacing.

In resurfacing work a consistent effort should always be made to correct faults that have developed during the life of the road. The comparatively large force of men and teams used for this work offers an opportunity for making needed betterments at a low cost. Excavations and embankments should be widened and sloped, broken culverts repaired or replaced, protection walls built, bridges overhauled, weak road foundations reinforced and all the heavy work necessary to put the road in condition for economical maintenance accomplished.

Before resurfacing work begins a close examination of the road should be made to determine:

(1) The thickness of the old macadam;

(2) The quality of the stone and where it was obtained;

(3) The condition of the drainage;

(4) Type and amount of traffic on the road;

(5) Width of fills and cuts;

(6) Size of stone used and how prepared.

As a rule, it is wise to clean out ditches and true the cross-section of the road in the beginning. On side hills it is frequently desirable to move the ditch cleanings across the road with the grader and use the material to widen the embankment. Here again it is well to avoid disturbing well-sodded ditches and shoulders. A narrow strip may be pared off along each side of the macadam that will leave the road in good shape for resurfacing.

In general, if the road is very rough and the macadam has not worn down to the rubble base (if such a base is used) scarifying will be found to be desirable. But if the base is exposed I do not think it should be disturbed.

As a general rule, the softer the stone the larger the crushed stone should be. With a very soft rock I prefer to have 2 to 3 in. stone in the wearing surface. Also by using a large stone an excess of screenings is avoided in crushing. In Madison County, Kentucky, we were building the Berea Road of a very hard stone with little bonding quality. But a very satisfactory bond was secured by spreading a thin coat of 1-in. stone over the No. 2 stone, rolling and covering with screenings. In general, use the size of stone that will wear well with the quality of stone available.

On thin resurfacing it is frequently quite a problem to use the whole product of the crusher without laying crusher-run. In this case it is a good plan to use excess stone to fill holes and depressions using only the uniform screened stone in the surface. A uniform grading of stone is half the battle in the life of a macadam surface. In many states harrowing of the loose stone is required, and it is certainly very desirable. Because of the mixing of the stone I believe the use of the road grader for spreading should be encouraged. It is certainly an economical method of spreading.

In resurfacing, stone is usually spread to a feather-edge, and frequently it is unnecessary to resurface the full width of the old macadam. The road is generally worn thin in the center. In Bath County, Kentucky, we resurfaced badly worn macadam with an excellent quality of limestone gravel, using a harrow and roller, and very good results were secured.

Much otherwise good work is injured, and the cost increased by the use of too much screenings. I have found that the added cost of spreading screenings by hand from piles dumped on the shoulders about offsets the added cost of hauling the extra screenings used when they are dumped directly on the stone. It is seldom possible to put on a satisfactory coat of screenings in one application, and when screenings are dumped on the shoulders a supply is always handy to the bare spots that always show when the road is rolled and flushed.

Securing an adequate water supply convenient to the road is frequently quite a problem. It is a good plan to finish the macadam in the rain if showers come at the proper time, which they seldom do. A small gasoline pump, housed over for protection and mounted on wheels, is a good investment and does much to solve the water problem. By building a small earth dam across a dry stream sometime before the water is needed it is frequently possible to tide over a dry spell.

Reconstruction.

In many cases roads that were well built and suited conditions at the time they were constructed, through neglect or a change in traffic conditions, have become so badly worn that it is advisable to rebuild them completely.

Except that the old foundation should be retained so far as possible, the principles that apply to new construction hold for reconstruction. But since the value of this foundation is frequently greatly reduced because of faulty alignment or excessive grades, all necessary betterments and charges should be made without delay.

Slotted Pot with Abrasion Machine for Testing Purposes.—A slotted pot was used last season in connection with the stone abrasion machine of the New York Highway Commission in testing slag. It was found that the tests on this material run in the standard stone abrasion machine were not indicative of quality or comparable with different qualities of stone, because the material worn from the sample during the test filled corners of the closed pot, and as soon as sufficient material had accumulated, a cushion was formed which greatly reduced the abrasion. A new pot was designed to remedy this condition. This is of the same size and shape as the standard pot, but it is slotted at intervals to allow the worn-off material to escape and to prevent cushioning. The new test has been very successful in determining qualities of slag. It has been also used in testing gravel with promising results. In testing gravels, several methods have been tried with charges of steel shot both in the closed and the slotted pot. So far, judging from results obtained, the most reliable method is in using the slotted pot without any charge.

Surface Treatment of Waterbound Macadam.—In 1915 the New York State Highway Commission started surface treating its macadam roads with about ¼ gal. per square yard of tar after the road had been subjected to traffic for a period of three months. For work not so seasoned a treatment of calcium chloride is provided that will carry it over the winter until it can have a protective coat placed upon it by the Maintenance Department. According to the last annual report of H. E. Breed, Deputy Commissioner in charge of construction this surface treatment has proved so satisfactory that it will be continued on all State construction contracts. It is stated that the treatment not only preserves the integrity of the surface of the waterbound macadam roads when they are new, but it decreases the cost of subsequent maintenance and leaves the road in excellent condition.

BITUMINOUS SURFACES.

Road oils and tars considered from the standpoint of their use in connection with the maintenance of broken stone and gravel roads were discussed by Prof. Arthur H. Blanchard, Consulting Highway Engineer, New York City, in a paper presented April 13 at the 4th Canadian and International Good Roads Congress. In his paper, an abstract of which is given below, the subject was presented with a view to general adaptability of conclusions and recommendations, and conservative practice only was advocated. Local conditions must always be given weight in the final determination of the method and material to be used.

Bituminous Materials.—Considerable development has taken place in the use of different kinds of bituminous materials. Tars, of both water-gas and coal-gas types, continue to be used to a large extent. During the past two years an asphalt cutback with naphtha has been successfully employed in the construction of bituminous surfaces.

Specifications Covering Bituminous Materials.—The following specifications for refined tars, used hot, and cutback asphalt for surface treatments have given satisfactory results:

Water Gas Tar: (1) The refined tar shall be homogeneous, free from water and shall not foam when heated to 121° C. (250° F.)

(2) Its specific gravity at a temperature of 25° C. (77° F.) shall be not less than 1.140 nor more than 1.160.

(3) When tested by means of the New York Testing Laboratory Float Apparatus, the float shall not sink in water maintained at 50° C. (122° F.) in less than 45 seconds nor more than 65 seconds.

(4) Its bitumen as determined by its solubility in chemically pure carbon disulphide at room temperature, shall be not less than 96.0 per cent and it shall show not more than 0.2 per cent ash upon ignition of the material insoluble in carbon disulphide.

(5) When distilled according to the method adopted by the American Society for Testing Materials in 1916, it shall yield no distillate at a temperature lower than 170° C. (338° F.); not more than 20.0 per cent shall distill below 270° C. (518° F.), and not more than 30.0 per cent shall distill below 300° C. (572° F.).

(6) The melting point as determined in water by the cube method, of the pitch residue remaining after distillation to 300° C. (572° F.) in accordance with the test described in Clause (5) shall be not more than 75° C. (167° F.).

Coal Tar: (1) The refined tar shall be homogeneous, free from water, and shall not foam when heated to 121° C. (250° F.).

(2) Its specific gravity at a temperature of 25° C. (77° F.) shall be not less than 1.170 nor more than 1.230.

(3) When tested by means of the New York Testing Laboratory Float Apparatus, the float shall not sink in water maintained at 50° C. (122° F.) in less than 40 seconds nor more than 100 seconds.

(4) Its bitumen as determined by its solubility in chemically pure carbon disulphide at room temperature, shall be not less than 82.0 per cent nor more than 95.0 per cent, and it shall show not more than 0.2 per cent ash upon ignition of the material insoluble in carbon disulphide.

(5) When distilled according to the method adopted by the American Society for Testing Materials in 1916, it shall yield no distillate at a temperature lower than 170° C. (338° F.); not more than 20.0 per cent shall distill below 270° C. (518° F.), and not more than 25.0 per cent shall distill below 300° C. (572° F.).

(6) The melting point as determined in water by the cube method of the pitch residue remaining after distillation to 300° C. (572° F.) in accordance with the test described in Clause (5) shall be not more than 75° C. (167° F.).

Cut-Back Asphalt (Philadelphia Specification): The material shall be a cut-back asphalt prepared in a still by compounding approximately 35 per cent of a distillate meeting Specification "A" and 65 per cent of an asphalt meeting Specification "B."

Specification "A": Beaume gravity, 53 to 60, Endpoint of distillation, 350° F.

Specification "B": Specific gravity, 77° F., 1.02 (minimum). Penetration, 100 grams in 5 seconds at 77° F., 85 to 100. Loss 50 grams, 5 hours, 325° F., not more than 3 per cent. Soluble in carbon bisulphide, not less than 99½ per cent. Soluble in carbon tetrachloride, not less than 99 per cent. Ductility (Dow method) at 77° F., not less than 45 cm.

The Cut-back asphalt made from a combination of the above two products shall conform to the following tests: Specific gravity, 0.900 (minimum). Penetration of residue after heating for 5 hours 325° F., from 35 to 45. Viscosity, 50 c.c., at 77° F., in Engler Viscosimeter, 275 to 350 seconds. Distillate off below 300° C. shall show a gravity of 53 to 60 Beaume. Ductility of residue (Dow method) not less than 30 cm.

Methods of Construction.—In the case of broken stone and gravel roads, the most efficient method of procedure is to clean the surface thoroughly by sweeping with hand brooms, or horse sweepers and hand brooms, the final sweeping being done with bass or other fine-fibre brooms. The bituminous material, which is used both cold and hot, is applied to the surface in amounts varying from ¼ to ½ gal. per square yard, with the aid of pouring cans, hose attached to tanks, hand-drawn gravity distributors, horse-drawn or motor-truck gravity or pressure distributors. Some kind of mineral coating is generally applied to cover the bituminous material. The degree of cleanliness of the surface obtained by sweeping will depend to a large extent upon the details of the original construction. It has been found that a road with a thoroughly rolled and well puddled broken-stone wearing surface, composed of road metal from 1 in. to 2½ in. in longest dimension may be easily cleaned, and the essential adhesion of the bituminous surface readily secured. This method is characteristic of the modern practice of many of the foremost English and French engineers.

Specifications Covering Construction.—As an illustration of the method of covering essential details of construction of bituminous surfaces with hot tar, the following specifications for certain local conditions are cited.

Heating Refined Tar: The refined tar shall be heated in kettles or tanks so designed as to admit of even heating of the entire mass, with an efficient and positive control of the heat at all times. It shall be heated as directed by the engineer to a temperature between 93° C. (00° F.) and 121° C. (250° F.). All refined tar heated beyond 121° C. (250° F.) shall be rejected. No tar shall be heated in kettles or tanks containing any oil or asphalt cement. The contractor shall provide a sufficient number of accurate, efficient, stationery thermometers for determining the temperature of the refined tar in kettles or tanks.

Preparation of Surface Road: All sections of broken stone roadways containing depressions, pot-holes, waves, ruts or other irregularities shall be repaired as directed by the engineer, prior to the final preparation of the road for the construction of the bituminous surface, by the use of broken stone which will pass over a ½-in. screen and through a 1½-in. screen, stone screenings passing a ¼-in. screen, and water, which materials shall be thoroughly compacted by tamping or rolling. Prior to the application of the refined tar, the surface of the broken stone road, when thoroughly dry, shall be swept clean of all dust, dirt or other loose material by using, first, stiff fibre hand brooms or a horse-drawn stiff fibre sweeper, and, second, bass or other fine fibre brooms, as directed by the engineer. When the cleaning is completed the upper surface of broken stone shall be exposed, forming a clean mosaic surface.

Application of Refined Tar: After the surface shall have been cleaned to the satisfaction of the engineer, and when thoroughly dry, the refined tar shall be uniformly applied over the prepared surface of the road by means of a pressure distributor as hereinafter specified and in accordance with the directions of the engineer. The refined tar, with applied, shall have a temperature between 93° C. (200° F.) and 121° C. (250° F.). The total amount of refined tar to be used in the construction of the bituminous surface shall be applied in one application and shall not be less than 0.35 nor more than 0.45 gal. per square yard, the precise quantity being determined by the engineer.

Pressure Distributor: The pressure distributor employed shall be so designed and operated as to distribute the refined tar specified uniformly under a pressure of not less than 20 lb. nor more than 75 lb. per square inch in the amount and between the limits of temperature specified. It shall be supplied with an accurate stationery thermometer in the tank containing the refined tar and with an accurate pressure gage so located as to be easily observed by the engineer while walking beside the distributor. It shall be so operated that, at the termination of each run, the refined tar will be at once shut off. It shall be so designed that the normal width of application shall be not less than 6 ft. and so that it will be possible on either side of the machine to apply widths of not more than 2 ft.

Application of Broken Stone Chips: Immediately after the application of the refined tar, a layer, between 12 and 15 lb. per square yard, of broken stone chips, which will pass through a ½-in. screen and over a ¼-in. screen, shall be spread and broomed as directed by the engineer over the surface of the refined tar and shall be at once rolled as directed by the engineer with a roller weighing between 5 and 12 tons.

Interruption of traffic: In cases where the entire roadway cannot be closed to traffic during the construction of the bituminous surface, only one-half of the roadway surface shall, at one time, be closed to traffic while the bituminous surface is being constructed thereon. The bituminous surface shall not be subjected to traffic until after the covering of broken stone chips has been rolled.

Seasonal and Weather Limitations. No refined tar shall be applied when the air temperature in the shade is below 10° C. (50° F.), except by the written permission of the engineer.

Failures of Bituminous Surfaces.—The causes of failure of bituminous surfaces are numerous. They may be considered from the standpoint of the condition and character of the original surface, the material used, the method of construction, and local conditions.

The failure of bituminous surfaces from the standpoint of the character of the original surface is many times due to failure on the part of those in charge to place the surface in satisfactory condition before the application of the bituminous material. Many cases are noted where bituminous materials are applied over a surface in which are found many pot-holes and ruts, or which is dirty, due either to accumulated dust and dirt or to the original method of construction. In many cases a damp condition of the surface has resulted in failure.

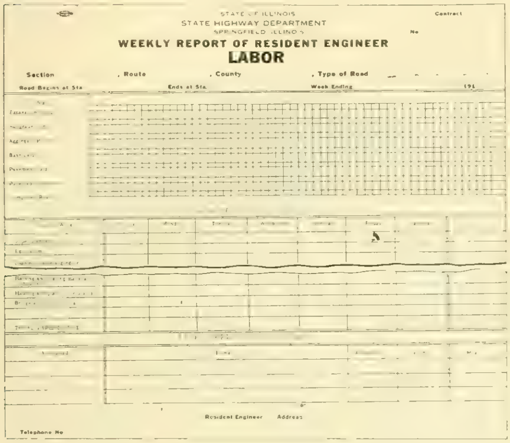
From the standpoint of the physical and chemical properties of the material, many instances may be cited in which failure is due to materials not having the proper characteristics for the conditions under which they are employed. The large percentage of volatile constituents contained in certain asphaltic oils has rendered surfaces constructed with them unsatisfactory because of the long period required for these surfaces to set up so that the bituminous material will not track or the carpet thus formed will not creep and form waves and humps. In certain cases the use of light oils on tar or asphalt surfaces has softened the original bituminous surface to such an extent as to render the road or pavement unsatisfactory for use.

From the standpoint of construction, failures are due both to the use of too small an amount of the bituminous material and to an excess of material. Improper application, resulting in uneven distribution, is accountable for many failures of bituminous surfaces, while in other cases a lack of sufficient covering of stone chips or material of a similar character has rendered the surface sticky and mushy.

There are numerous instances where bituminous surfaces have been adopted under conditions which call for the construction of bituminous concrete pavements or even some type of block pavements. A mat type of construction, which has been employed to a considerable extent, has proved inefficacious in cases where the amount of motor-car traffic was not sufficient to iron out satisfactorily the calk holes caused by the horse-drawn vehicle traffic.

LABOR AND MATERIAL REPORT FORMS USED BY RESIDENT ENGINEERS OF ILLINOIS HIGHWAY COMMISSION.

Revised report forms for labor and material used in state aid highway construction have been put in service recently by the Illinois State Highway Department of which Mr. Wm. W. Marr is chief state highway engineer. These forms cover a calender week and are filled in by the resident engineers. The sheet used for the weekly report on labor is illustrated in Fig. 1. A particularly useful feature of this blank is the chart at the top for indicating graphically the progress of the various features of the work. This is done by filling in the lines in solid black and by crosshatching the length of construction covered.



STATE OF ILLINOIS
STATE HIGHWAY DEPARTMENT
SPRINGFIELD ILLINOIS
WEEKLY REPORT OF RESIDENT ENGINEER
LABOR

Contract
No

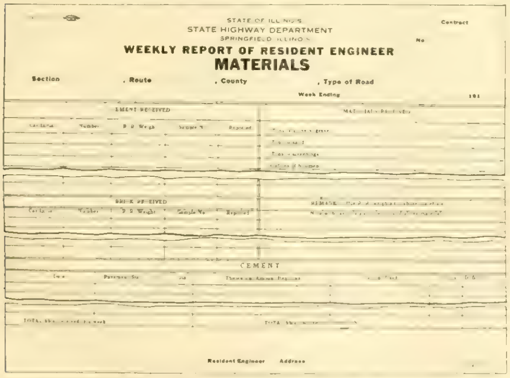
Section , Route , County , Type of Road

Road Begins at Sta Ends at Sta Week Ending 191

Resident Engineer Address

Telephone No

Fig. 1—Blank for Weekly Labor Report of Resident Engineers of Illinois State Highway Department.



STATE OF ILLINOIS
STATE HIGHWAY DEPARTMENT
SPRINGFIELD ILLINOIS
WEEKLY REPORT OF RESIDENT ENGINEER
MATERIALS

Contract
No

Section , Route , County , Type of Road

Week Ending 191

CEMENT

Resident Engineer Address

Fig. 2—Blank for Weekly Material Report of Resident Engineers of Illinois State Highway Department.

Under the heading, "Labor Report in Money," space is provided for each item of work that would be likely to be involved in the improvement. In all 27 items are given on blank, each one having a separate line. Only a few of their sub-divisions are shown in the illustration, the remainder being omitted in order to reduce the size of the cut. The 27 items of work listed are as follows:

Superintendence.
Excavation.
Loading coarse aggregate.
Hauling coarse aggregate.
Loading fine aggregate.
Hauling fine aggregate.
Loading and hauling cement.
Loading and hauling bituminous materials.
Loading and unloading brick.
Hauling brick.
Incidental hauling.
Shaping and rolling subgrade.
Mixing and placing concrete handling forms and joints.
Covering, seasoning and cleaning concrete.
Placing and preparing sand cushion.
Laying and rolling brick.
Grouting joints in brick.
Spreading stone.
Rolling and sprinkling.
Heating bituminous binder.
Applying bituminous binder.
Mixing and placing bituminous concrete.
Shaping and rolling earth shoulders, gutters and side roads.
Mixing and placing concrete gutters.
Hauling and placing macadam shoulders.
Hauling and placing tile drains.
Bridge and culvert work.

The space under the heading "Extra Work Not in Contract" is utilized for listing all extra work not included in the contract, for which the contractor is paid actual cost plus a per cent.

The weekly report blank for materials is shown in Fig. 2. The state highway department furnishes all cement for the state aid road contracts, and accordingly the blank has been especially designed to care for this feature. The department also may on proper authorization by the contractor pay the brick company for all brick delivered on the job. The other materials are furnished by the contractor and so only the total amount received by him is noted.

For its state aid road work Illinois is divided into seven districts, each in charge of a division engineer. The resident engineers send one copy of their report to their division engineer and one copy to the road engineer of the State Highway Department.

DURAX PAVEMENT CONSTRUCTION AT DAYTON, O.

During 1916 the city of Dayton, O., laid several thousand square yards of Durax pavement between car tracks. On Main St. 6,250 sq. yd. of this type of small granite block pavement were put down at a cost of $3.50 per square yard and on Fifth St. 4,185 sq. yd. were laid at a cost of $3.70 per square yard. This year 4,700 sq. yd. of Durax pavement will be laid on Jefferson St. and a portion of Third St., covering 19,400 sq. yd. will be entirely paved with this concentric interlocking pavement. The Jefferson St. work will cost $3.65 per square yard and the Third St. improvement $3.70. The above prices are for the pavement complete, including the excavation, 6-in. concrete base, mortar cushion and grout filler.

Laying Durax Pavement at Dayton, Ohio.

The Dayton specifications for Durax pavement provide that the cubes shall be of medium grained granite having a crushing strength of about 30,000 lb. per square inch, combined with a uniform structure and toughness of 12, as determined by the method employed by the Department of Agriculture of the United States Government, Office of Public Roads, from samples taken directly from the quarry. It also is specified that the cubes shall have six irregular, approximately square surfaces, the edges of which shall measure not more than 4 in. and not less than 2¾ in. It is provided the blocks used on any one city block shall not vary more than ¾ in. in size; that is, either from 2¾ to 3½ in., or from 3¼ to 4 in.

After the concrete base has been poured, brought to grade by use of templets, and has had sufficient set to permit paving operations, a mortar cushion 1¼ in. thick is laid on the concrete.

This mortar cushion is composed of 1 part Portland cement and 4 parts of dry, clean, sharp sand, thoroughly mixed in an approved machine mixer. It is not less than ½ in. nor more than 1¼ in. in thickness after the blocks have been placed.

On this mortar cushion, Durax blocks are laid in concentric interlocking segments, care being taken to break joints as much as possible. No part of the joint must exceed ½ in. at the surface or be less than ¼ in.

Immediately after the blocks are laid, sufficient coarse dry gravel or crushed stone is spread over the surface and swept into the joints to fill the space between the blocks to a depth of about 1 in. The blocks then are rolled with a not less than 5-ton roller to thoroughly settle and compact the first layer of gravel in the joints and so as to leave no blocks above or below the general surface of the finished pavement. After the Durax blocks have been placed, and brought to grade by rolling or tamping, the paved surface is sprinkled, allowing sufficient water in the joints to moisten the mortar cushion.

The grout filler is composed of 1 part cement to 1 part sand and is applied in a manner similar to that for brick pavements. A 1-in. expansion joint is provided along the curb.

In the Dayton work the pavement proper costs about 25 ct. per square yard for the labor and laying, and is usually done by sub-contract. One paver lays about 25 sq. yd. in 8 hours. Mr. F. O. Eichelberger is Chief Engineer of Dayton.

COST OF OPERATING MUNICIPAL ASPHALT PLANT OF DISTRICT OF COLUMBIA.

All minor repairs of asphalt pavements in the District of Columbia are made from the output of a portable municipal asphalt plant. This plant also is employed in furnishing product for the construction of an asphalt macadam wearing surface on old macadam streets. The plant, a Warren Bros.' portable asphalt plant, with a nominal capacity of 100,000 lb. per day was purchased and installed in 1912 at a cost of $6,900. Since that date it has been operated from 220 to 240 days per year, with an average output of about 80 per cent of its capacity.

During the fiscal year ending June 30, 1916, the plant was operated 236 working days, with an average daily output of 715 cu. ft. and a total output of 168,684 cu. ft. Old material was used to considerable extent. Old asphalt topping removed from the streets in resurfacing was crushed to a finely broken product to which was added the new material. The use of this old topping resulted in a substantial saving. A Noyes crusher purchased of C. E. Rollo, First National Bank Bldg., Chicago, Ill., was used for breaking up the old material. The cost of the crusher, including a portable engine and boiler, was $1,910.

The following data on the work of the municipal asphalt plant for the last fiscal year are taken from the last report of the operations of the Engineer Department of the District of Columbia:

The following amounts of materials were purchased for use in manufacturing the output during the year:

Sand, 2,160.50 cu. yd. at	$ 1.03
Asphaltic cement, 461.4 ton at	10.00
Limestone dust, 205 ton at	2.53
Screenings, 855 ton at	1.32

There was purchased for use in operating the crusher and mixer the following large items:

Fuel oil, 23,927 gal. at	$0.031
Coal, 170 ton at	3.45
Wood, 80 cord at	5.00

The costs of operation, including material and labor, are kept from day to day, and the summary of this data for the fiscal year ending June 30, 1916, develops the following unit costs for the year's operations:

OPERATION OF CRUSHER.

Period of operation, 52 working days, output of crusher, 2,327 cu. yd.	
Labor and fuel ($1,320.06 plus $83.20)	$1,403.26
Cost per cu. yd., $0.603.	
Maintenance, renewals and repairs	83.04
Cost per cu. yd., $0.0357.	
Overhead costs:	
Capital invested, $1,910, at 3½ per cent	$ 66.85
Obsolescence, 5 years, at 20 per cent	382.00
Cost per cu. yd., $0.193.	
	$ 448.85

Cost of crushed product, per cu. yd.:	
Labor and materials	$ 0.603
Repairs to plant	.036
Overhead	.193
	$ 0.832

OPERATION OF PLANT.

Period of operation, 236 days; total output, 168,684 cu. ft.	
At plant:	
Labor (3.56 ct. per cu. ft.)	$ 6,004.18
Fuel oil (0.56 ct. per cu. ft.)	776.68
Coal (0.27 ct. per cu. ft.)	455.80
Wood (0.13 ct. per cu. ft.)	223.60
Binder stone	82.50
Tool repair (0.20 ct. per cu. ft.)	329.66
Total (4.71 ct. per cu. ft.)	$ 7,872.42
Haul from plant to street:	
Labor (3.85 ct. per cu. ft.)	$ 5,904.05
On street:	
Labor (12.3 ct. per cu. ft.)	$18,905.53
Painting joints (0.15 ct. per cu. ft.)	236.00
Wood (0.13 ct. per cu. ft.)	223.60
Tool repair (0.10 ct. per cu. ft.)	164.63
Total (12.68 ct. per cu. ft.)	$19,529.96
Maintenance and repairs:	
At plant (0.22 st. per cu. ft.)	$ 365.93
On street (0.15 ct. per cu. ft.)	228.94
Total (0.37 ct. per cu. ft.)	$ 594.87
Total (0.37 ct. per cu. ft.)	$ 594.87
Overhead:	
Capital invested, $6,900, at 3½ per cent	$ 241.50
Obsolescence, 5 years, at 20 per cent	1,380.00
Total (1 ct. per cu. ft.)	$ 1,621.50
Supervision:	
Foremen and overseers (3.7 ct. per cu. ft.)	$ 6,239.67

Total manufacturing costs per cu. ft.:	Cents.
Plant, labor	4.71
Hot haul	3.85
Street work	12.68
Maintenance of plant and tools	.37
Overhead—	
Interest and obsolescence	1.00
Supervision	3.70
	26.31

The sand used was bought under a contract at 44 ct. per cubic yard and hauled from the wharf to the plant at a cost of $1,266.26 for 2,160.5 cu. yd., or 59 ct. per cubic yard, a total of $1.03 per cubic yard. All the other material was delivered at the plant site at the costs shown below.

The cost of cubic foot of old material mixture was as follows:

0.67 cu. ft. crushed material, at 83.2 ct. per cu. yd.	$0.0206
0.27 cu. ft sand, at $1.03 per cu. yd.	.0103
3.89[1] lb. asphaltic cement, at $10 per ton	.0195
Total material	$0.0530
Manufacturing and placing cost	.2631
Total (cu. ft.)	$0.3161

Asphaltic concrete mixture:	
0.5 cu. ft. screenings, at $1.32 per ton	$0.0330
0.5 cu. ft. sand, at $1.03 per cu. yd.	.0190
4.2 lb. limestone dust, at $2.53 per ton	.0053
9.16[1] lb. asphaltic cement, at $10 per ton	.0458
Total material	$0.1031
Manufacturing and placing costs	.2631
Total per cu. ft.	$0.3662

[1] Includes 10 per cent tare.

The plant operating force consisted of one foreman at $100 per month and the following per diem employes:

1 Steam engineer (operating mixing plant) at	$3.50
1 Steam engineer (operating crusher) at	3.00
1 Timekeeper at	3.00
7 laborers (operating plant) at	1.75
12 laborers (operating crusher) at	1.75
4 laborers (miscellaneous, including watchman) at	1.75
12 carts* (hot haul) at	2.50

*Hauling hot material from plant to street operating or patching gangs.

There are two patching gangs, each of which consists of the following units of per diem employes:

1 Foreman at	$4.00
5 Skilled laborers (1 shoveler, 2 rakers and 2 tampers) at	2.25
5 Skilled laborers (rollermen, cutting out and miscellaneous) at	2.00
10 Skilled laborers (miscellaneous) at	1.75
2 Wagons (hauling old material to dump and hauling barricades), at	5.00
1 Cart (hauling tool and fire wagons) at	2.50

In connection with the supervision of the above there are two inspectors, one of which is employed at a salary of $125 and the other at $100 per month. These men are held responsible for the character and performance of all the work, prepare all statements and reports in connection therewith and map out the various routes to be followed. The street paving and maintenance work in the District of Columbia is carried out under the general direction of Mr. C. B. Hunt, Engineer of Highways.

JAPANESE ROADS AND HIGHWAY BRIDGES.

Contributed by J. L. Harrison.

The first impression one gains on viewing Japanese roads is that they seem narrow.

In comparison with American roads they are narrow, for even the best roads which the writer saw seldom exceed 12 ft. in width. Many of them are not over 6 or 8 ft. wide. However, outside of the cities where the principal streets are wider, there is no crowding for practically all the vehicles are narrow man-drawn carts and carriages, and to accommodate constant two-way traffic of this kind, a width of not over 8 ft. is necessary.

A Japanese coolie will take one of the light rickshaws found in every part of Japan and haul a heavy passenger over a smooth, dry, level road at a speed not much if any below what would be expected of an ordinary team of horses in the United States and will cover almost as much distance in a day. The surplus power of these human horses seems to be decidedly limited and it has, therefore, been necessary for Japanese road builders to keep this fact constantly in mind in all of their road and street construction. In going about a Japanese city or in traveling through the country one notices the extremely heavy cuts which are the Japanese solution for what would otherwise be a hilly and irregular profile. Just what is done with the material taken from these cuts does not appear for the Japanese love of deep cuts seems to be only equaled by his aversion to high fills. There may be some reason for this, but a close examination of the soils in various cuts did not reveal anything which would impress an ordinary engineer as rendering them unfit for the construction of fills.

This habit of attaining low grades by a process of extensive excavation appears to have been followed in the cities as well as in the country.

Many Japanese cities are built on very hilly ground and it is nothing uncommon to see side hill cuts 40 or 50 ft. deep in almost any parts of a city. The building sites are not excavated to street level, but are reached by long flights of steps, and the heavy stone facings by which the steep sides of these cuts are retained constitute one of the most interesting engineering studies in the whole of Japan. Of course cross streets are rare, or possibly it would be more accurate to say that cross streets for the use of wheeled vehicles are rare, for narrow cross streets ending in flights of step are common enough. But for obvious reason a street system built on the lines adopted in Japanese cities will be largely made up of more or less parallel streets one along the other with cross streets for the use of vehicles only where the topography makes their construction reasonably simple. All of this makes the layout of a Japanese city at first seem peculiar, but when the layout is studied in the light of the limitations of man-drawn vehicles, the logic of it all becomes very clear and one is compelled to admire the persistence with which this race has labored to live under its cumbersome universal man-power system.

There is a good deal of rain in the parts of Japan which the writer has visited. So the slightest mud greatly increases the tractive power required to move loads. The Japanese seem to be very careful to crown their roads rather heavily in an effort to prevent any water from standing on them. It is also extremely difficult for the man who must haul a load to keep warm during the cooler weather if his feet are constantly wet. This fact may also have a bearing on the evident effort to keep the metalled surface of all Japanese roads free from water. At any rate, one notices at once the fact that the improved roads of Japan shed water very quickly and that little or no mud is to be found on them.

Japanese roads are not as smooth as one might expect. In fact, smoothness does not seem to be highly regarded, though it cannot be said that Japanese roads are rough. The method of construction does not seem to include the use of rollers, even on the city streets, and indeed there is no real reason why it should, for there is no heavy traffic in those parts of Japan which the writer has visited. Therefore the surface of all Japanese roads is somewhat irregular as one would naturally expect where neither the subgrade nor the surfacing is rolled; but for the light man-drawn vehicles which use these roads, this is of trifling importance.

The metalled surface of most of the Japanese roads seems to be made of gravel or broken stone. Most of the roads seem to have a broken stone body and a light gravel top dressing. Of course all of the stone used is hand broken, so no screenings are available. This undoubtedly accounts for the fact that even for broken stone roads clay and light gravel are still used as binder and the road surface compacted by the traffic passing over it.

The surfacing of all modern roads seems to be thicker than the needs of the ordinary traffic would require and one obtains the impression that this must be a requirement of the national Government made in order to insure that these roads may be able to stand the exigencies of military operations. The fact that this careful consideration has been given is possibly somewhat more evident in

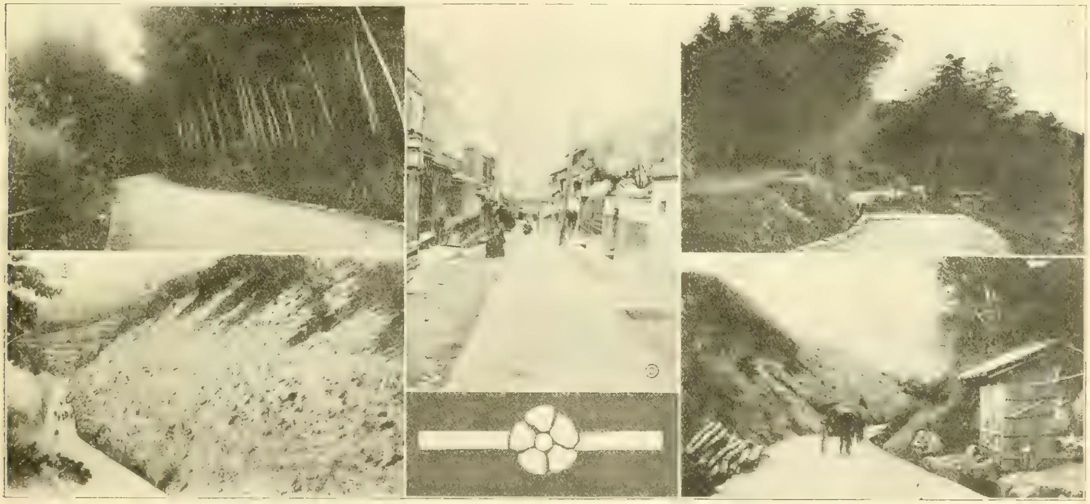


Fig. 1—The Mogi Road, a Typical Japanese Highway. Note the High Curvature. Fig. 2—A Typical Flat Stone Pavement. Fig. 3—Another View of the Mogi Road. The High Curvature Is no Great Hindrance to the Kind of Traffic Shown in the Picture but Steep Grades Are. Fig. 4—Cut on the Mogi Road. Cuts Like This Make Japanese Road Building Look So Peculiar for There Are No Fills to Balance Them. Fig. 5—Deep Cuts of This Sort Are Common in All Japanese Roads But by This Means Grades Are Kept Down.

Japan than it was in Europe before the war. For in European countries the peace traffic is relatively heavier than it is in Japan, but on the whole the consideration which has been given to the military side of road building is only another illustration of the fact that Japan takes her road system seriously.

The Japanese are so often spoken of as a race which makes progress only by copying the work of others that the evident independence of thought which has marked the road building operations of this country is indeed refreshing. One at first disapproves of the heavy cuts, the light grades, the steep side slopes, the narrow city streets and the almost equally narrow country roads, not to mention the entire absence of all of the more modern forms of pavements. But gradually the absolute adequacy of the system becomes so evident that one soon finds himself comparing it with the never quite adequate roads with which he is familiar at home. It is true that these roads are never quite adequate because they are never quite kept up to the ability of the truck builder to turn out a heavier machine; but, even so, one soon comes to feel that the Japanese government would long ago have solved the question as to the maximum size of trucks, the added cost of pavements and the added cost of maintaining these pavements being considered, and that the same condition of absolute and complete adequacy would still have been preserved.

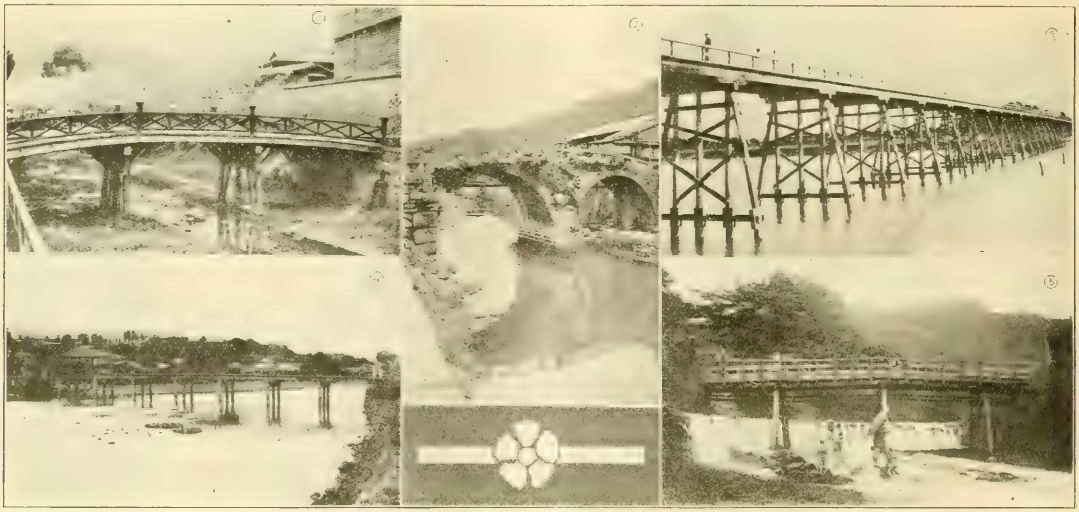


Fig. 1—Japanese Highway Bridge. American Engineers Would Have Braced This Bridge Very Differently. Fig. 2—An Old Fashioned Cut Stone Arch Bridge. Fig. 3—A Long Pile Bent Bridge Near Nogasaki. Fig. 4—An Interesting Highway Bridge. Note Absence of Braces. The Light, Low Velocity Traffic Doubtless Has Much to Do With Making This Permissable. Fig. 5—A Typical Japanese Timber Highway Bridge.

It has been mentioned that the so-called modern pavements are practically unknown in Japan. There is no traffic heavy enough to justify their construction. That seems to be the whole root of the matter. On the other hand, the Japanese do pave some streets with flat stones and one frequently sees flat stone wheelways on heavy grades. The obvious purpose of these flat stone wheelways is to reduce traction to a minimum, but the reason for paving streets with flat stones is not so clear. It may be that these streets are remnants left over from a time when the construction of broken stone roads was not as well understood as it is now. At any rate, such pavements are not very common now and in fact seem to be disappearing.

Japanese bridges are undergoing a transition. The oldest permanent structures are, as one would expect, cut stone arches. Many of these are constructed without mortar in the joints. They are well built and are, of course, permanent as long as they are not overloaded or washed out. Then one sees numbers of wooden structures. These are usually pile bridges, though one sometimes sees timber arches, and an occasional timber truss. These structures seem to be the remnants of an old regime or the temporary crossings built to endure only until money for permanent work is available. The pile bridges are always interesting for the lack of bracing is very evident. But timber is expensive in Japan and loads are light, so that these structures, like all Japanese road and bridge work, are logical.

From time to time one finds a new bridge, a concrete slab and girder or a concrete arch and rarely a steel truss. These structures are typically Japanese, but they represent the steadily applied effort to modernize all bridges and to make them as strong and permanent as the roads. In this the Japanese seem to be progressing rather slowly but rather steadily.

One finds in the Japanese road system nothing new that he would be justified in applying to an American road system, for those things which are new to him are made possible by the light loads which these roads must carry and the cheap labor which has been used in constructing them. The loads which he must deal with are heavy and the labor he hires is expensive, so Japanese roads must be looked on as interesting and Japanese ideas as well worked out for Japan, but as inapplicable to American conditions.

On the other hand, one cannot go over the Japanese roads without carrying away a wholesome respect for the governmental system which has made it possible to first determine the needs of the country and then to set about to meet those needs. One sees no unmaintained roads, and there is no evidence that the local ward politician is permitted to show his engineering ability by trying every newly devised pavement folly, or that the provincial engineer could possibly exercise the freedom of judgment which exercise permits an American engineer to lay a 2-in. concrete base for a rural brick highway under the mistaken impression that he is constructing a substantial road. Everything in Japan seems to be carefuly thought out and co-ordinated before any effort is made to put it into practice. The roads are never too light. They never give the impression of being haphazard. They never appear accidental or out of place. So one leaves Japan with the feeling that though the roads there are so different from those with which he must deal at home that he can learn little from the roads themselves, the system under which they are built is a wonderful system and worthy of the careful consideration of any one who is interested in bettering the systems under which most American roads are now constructed.

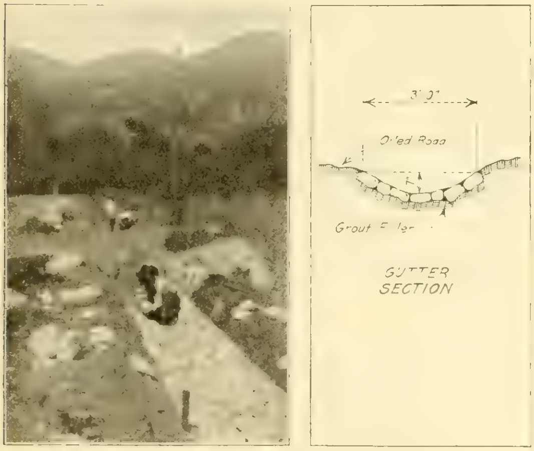
COST OF A COBBLE LINED GUTTER IN LOS ANGELES COUNTY, CALIFORNIA.

Contributed by E. Earl Glass.

To prevent cutting by storm water, the Los Angeles County Road Department recently constructed a cobble lined gutter on each side of a steep hillside road. The adjoining property owners furnished the cobbles and gravel, which they hauled from an nearby stream bed.

The gutter was roughed out with plow and slips and shaped with shovels. The soil being a very sandy silt furnished an excellent bed for the stones. Excepting the team work on rough grading, all the work was done by three laborers with part of the time of a road foreman.

The best stones for this work are hard, clean, stream cobbles, about 6-in. x 10-in. faces and 4 or 5 in. thick. Cobbles are often laid vertically or at a slight angle on this work as on street pavements, but we laid this work flat, thus effecting a great saving in time and material, and getting practically the same results.



View and Section of Cobble Lined Gutter.

After 400 ft. of gutter had been laid, one of the men would go back and wet the gutter until water showed between the stones. He then tamped every stone with a sledge. He mixed half-bag batches of coarse mortar (1:3:5) in a mortar box and shoveled the soupy grout onto the wet stones. Another laborer swept the mortar along with a street broom, filling all voids between the stones with the concrete and leaving the gutter section smooth but showing all rock faces. As soon as the mortar was sufficiently set, an inch depth of earth was spread over the finished gutter and kept damp for a week.

At all driveways and in front of residences where a deep, open gutter would be objectionable, the property owners provided 14-in. concrete pipe which were laid in shallow trenches with open joints. The gutter was flared to connect with these pipe culverts, providing substantial and artistic head walls, with generous capacity for entry and delivery of a full stream of storm water.

The cost of the improvement was as follows:

	Pipe.	Gutter.	Total.
Length, ft.	224	1,656	1,880
Excavating and backfilling	$16.50	$218.75	$235.25
224 lin. ft. of 14-in. concrete irrigation pipe @ 33 ct. delivered	74.00	....	74.00
30 tons (25 cu. yd.) of bank gravel for grouting	....	8.00	8.00
367 tons of clean, granite cobbles for paving gutter	....	103.00	103.00
Laying stone for pipe end walls and paving gutter	17.50	243.50	261.00
Grouting end walls and gutter	4.50	60.70	65.20
Cement for end walls and gutter, 28½ bbl. @ $2.00	3.50	53.50	57.00
Supervision	18.00	87.00	105.00
Total	$134.00	$774.45	$908.45
Total cost per lin. ft.	$0.60	$0.166	$0.483
Total cost per sq. ft. of paved surface		$0.043	

Note—Labor, $2.50 per 8-hour day.

Twenty-three yards of 1:3:5 concrete were used in grouting, which is a rate of 0.14 cu. yd. per 100 sq. ft. of cobble-gutter surface. Labor only for laying and grouting (no grading) was $6.60 per 100 lin. ft., or the three men finish 114 lin. ft. per day, exclusive of excavation.

A METHOD OF PRORATING THE COST OF PAVEMENTS.

A simple method of assessing the cost of paving was described by Mr. C. H. West in a paper printed at the last annual meeting of the Minnesota Surveyors and Engineers' Society. The method was outlined as follows:

Assume a certain width of pavement as conferring only local benefits. This might be taken as 12 ft. out from the curb on each side of the street and would extend an equal number of feet beyond the curb at the intersecting streets. The balance of the pavement would be paid from the general paving fund, on the theory that the only logical reason for its existence is the requirements of the foreign traffic.

The estimated cost per square yard multiplied by the yardage will furnish the amount to be assessed to that portion of the block within the assessment district.

A diagram is then prepared to show the relative proportion of the cost that each lot shall bear. Upon an ordinary piece of cross-section paper, a quadrant of a circle is described, the radius of which is equal to the distance back from the street line to the limit of assessment. The intersection of the curve of the horizontal radius is marked zero, and from this point every ten feet, according to scale, is erected an ordinate to the circle. The length of these ordinates can be obtained by inspection and should be divided by the length of the radius. This percentage of the long ordinate should be marked upon each ordinate and intermediate ordinates may be proportioned.

The explanation of the use of this diagram can best be made by illustration. Figure 1 represents the diagram just described, and Fig. 2 represents a somewhat unusual block where this method of assessment was used.

By referring to Fig. 2, it is found that lots 1, 2, 3, 4, 5 and 6 extend 90 ft. back from the street line, and according to Fig. 1 the ordinate corresponding to 90 ft. is equal to .891. This amount multiplied by the frontage of the individual lots will give the number of units for each lot. In like manner the ordinate for 120 ft. is .962 and when multiplied by 38, 26 and 24 will give the units for lots 7, 8 and 9, respectively.

The number of units for so much of lot 10 as lies within the district will be found by multiplying the width of the lot parallel to the improved street, which in this case is 126 ft., by the difference between the ordinates corresponding to 132 ft. and 165 ft., the latter distance being the limit of assessment. By the same method, the values of lots 23, 22 and the northerly 11 ft. of 21 are secured. The sum of all the units is then divided by the amount to be assessed to the block and the value of each unit determined. It is then an easy matter to make the assessment.

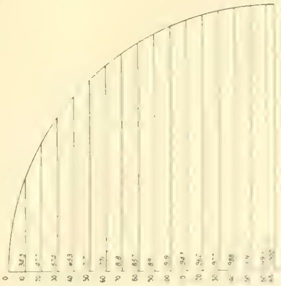


Fig. 1.

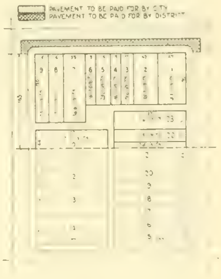

PAVEMENT TO BE PAID FOR BY CITY
PAVEMENT TO BE PAID FOR BY DISTRICT

Fig. 2.

California counties during the last six years have expended the sum of $74,740,012 in road and bridge construction and maintenance, the yearly totals showing the following increase: 1911, $9,069,637; 1912, $8,489,941; 1913, $11,744,446; 1914, $11,519,234; 1915, $15,021,565; 1916, $18,895,187; total, $74,740,012.

TRAFFIC CENSUS: ITS APPLICATION TO DESIGNS OF ROADWAY, SELECTION OF PAVEMENTS AND TRAFFIC REGULATION.*

In fixing the width of any roadway surface, the number of lines of traffic to be accommodated should be given consideration. The statement has been made that, where a vehicle has to turn off a hard surface of a road onto an earth shoulder oftener than five times in a mile, it is cheaper to construct the additional width of road surface which may be required, and is far safer.

Now, the necessary amount of clearance which a vehicle must have to pass safely depends on the speed. The average width of vehicles in New York City has been found to be 6 ft. 9 in., large trucks occupying as much as 8 ft. or 9 ft. At slow speed, say 10 miles an hour, with the average width, the width of a single line of auto traffic, including clearance, would be about 8 ft., and at fast speeds 9 ft. or more. On Fifth Avenue in New York City, its busiest avenue, there are six lines of auto traffic, occupying 55 ft., the speed being between 5 and 8 miles per hour. It is obvious that, if the roadway had been made, say 3 ft. narrower, another line of travel—or possibly two—would have to be sacrificed. The width of the Fifth Avenue roadway was originally 40 ft., accommodating four lines, with too much clearance. It was widened 15 ft., and now takes six lines, with a safe clearance. It is obvious that great congestion would have occurred, and much inconvenience to the public, had the street continued with only four lines of traffic and its excessive width.

On a suburban or country road accommodating auto traffic, the additional clearance required by an overtaking car should be considered. When moving at, say 25 miles an hour, at least 4 ft. of free way should be given the overtaken car, to avoid accident due to unexpected deflection from its course. A width of 20 ft., for this reason, is better than 18 ft., for two lines of travel, and 30 ft. is ample for three lines.

In the Borough of Manhattan, a realization of the necessity for widening the narrow crosstown roadways of the mercantile district, and some of the north and south avenues as well, took shape in 1911, and has resulted since then in the widening of 14 streets and avenues 35,012 ft. in length, and apparently the work has just been begun. On all of these streets, a 10-hour census of the vehicular and pedestrian traffic was taken, and resulted in bringing to light places of unexpected congestion, and afforded clues as to how the traffic can be diverted. It was found that, where the maximum number of vehicles per foot of width per minute exceeded 0.5, there was such serious congestion, that a remedy needed to be applied; likewise, where the maximum number of pedestrians per foot of width per minute exceeded 5.0, that they flow over the sidewalks into the roadway. Where both these conditions obtained, the street would need to be widened. So far, this difficulty has been obviated by clearing the sidewalks of stoops, railings, court yards, areas and other projections, thus affording additional space for pedestrians, and then widening the roadway to accommodate the suitable number of lines of travel, provided such widening did not produce an unduly congested condition for the pedestrian traffic. The Traffic Census has made the strongest kind of supporting data for promoting legislation for the foregoing work, and shows indisputably the need, or otherwise, of street widening.

The influence of the per cent of horse-drawn traffic on the kind of pavement, its grade, and alignment should be given weight. In cities with intensive traffic, where more than 75 per cent is auto, sheet asphalt is, in the opinion of the writer, the pavement par excellence; if the traffic is evenly divided into rubber and iron tires, wood block stands out pre-eminently, while, for the slow moving horse-drawn traffic, amounting to more than 50 per cent of the whole, close jointed granite blocks are eminently satisfactory, these limitations to be applied, of course, where traffic conditions are considered as the controlling factors in forming a decision.

The difference in traction between these three kinds of pavement, as indicated by tests shown in a pamphlet on "Tractive Resistances of a Motor Truck," by A. E. Kennelly and O. R. Schurig, may be represented by the following factors, which are averages of tractive resistances at a speed of 19 miles per hour:

Pagevent.	Tractive resistances in lb. per ton.
Asphalt	19
Wood and brick	23
Granite	26
Macadam	22.5
Tar macadam	24.5
Gravel and cinder	26.5

The tractive resistances should, in the opinion of the writer, be given much greater weight in the selection of pavements in cities, than is usually accorded them, for the following reason: It will hardly be questioned that auto trucks, in the cities at least, will soon be in almost universal use, and when this is a fact, the consumption of fuel will undoubtedly be carefully examined into, and smooth, light traction surfaces demanded for economy of operation. Today, with the numerous pleasure autos in use, scant attention is paid to ease of traction, grade or consumption of gasoline, and a scenic highway is at times preferred to the shorter utilitarian route, for which there is going to be an urgent demand by the auto trucks, especially in rural districts.

A few figures as to the growth of the auto truck in New York state are presented. A report of the Secretary of State states that it is estimated that auto trucks traveled over state and county highways in 1915, for 40 weeks in the year, 14,700,000 miles, and that these trucks operated 60,200,000 ton miles. The number of auto trucks in New York State in the last three years is as follows:

1914	17,141
1915	20,880
1916	54,653

There were in New York City in 1916 about 21,000 auto trucks, double the number of 1914. In addition, there are more than 100 routes in the State over which heavy motor busses are operating, nearly all of which are less than three years old.

The traffic census finds its application to the regulation of traffic in large cities where congestion is imminent or actual. The Borough of Manhattan has found it necessary to establish 29 streets as one-way traffic streets. These are located largely in the mercantile and theater districts. Three of them are theater streets, with a one-way rule applying one-half hour before and after the termination of performances.

A determination of the amount of traffic in all the streets of any section of a city should indicate where a diversion of the flow is desirable. So far as the writer has been able to ascertain, but one study of the flow of traffic has been made, that being in the city of Bridgeport, Conn., by Alfred S. Miller, as published in the Engineering News of Jan. 21, 1916. The writer believes that such studies are highly important where there is intensive traffic on a gridiron system of streets, to the end that alternate traffic routes may be laid out by widening, paving, regrading or otherwise improving, so that congestion may be avoided and the orderly transaction of business facilitated.

A number of the large express companies and other corporations now route their vehicles, and have a regular patrol which keeps them constantly informed of the location. A study of the flow of traffic in a large, busy city may offer some difficulties, but would be helped out by instances such as the foregoing. In the Borough of Manhattan, the Fifth Avenue Association has influenced traffic on that avenue by encouraging merchants and others to exclude commercial traffic from this distinctly retail mercantile and residential thoroughfare, so that there is now less than 2 per cent of horse-drawn vehicles of all kinds. This association makes its own traffic censuses and studies traffic conditions quite independently of the city, and is in a position to make valuable recommendations as to the policy to be pursued. It was suggested to the

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*From a paper presented at the last annual convention of the American Road Builders' Association by D. B. Goodsell, engineer, Department of Public Works, Manhattan Borough, New York City.

Police Department that more time be given to the north and south traffic than to the east and west, with the result that about 45 minutes of the hour are devoted to the longitudinal travel, while the cross-town traffic takes up the remaining 15 minutes. It has been proposed to divert the through traffic of Fifth Ave. to a parallel avenue, thus affording some relief to this much congested thoroughfare.

It is daily becoming more apparent that, if the vehicular traffic is to proceed with reasonable speed, say 8 miles an hour on our busiest streets, it will be necessary to regulate the pedestrian traffic as well. It was found that the average time taken by a woman crossing Fifth Ave. —which has a width of 55 ft.—was 11½ seconds. In the busy hours, six vehicles would pass in that time, rendering the crossing difficult and dangerous. There is nothing to prevent a pedestrian from crossing the street at any time he may elect to do so, and he certainly needs to be told when, if the number of accidents which happen is a criterion.

The Traffic Census should include observations as to the direction of the flow of traffic, such as left-hand turns; number of vehicles emerging from or entering side streets; routes of mail trucks and other vehicles; wandering cabs, etc., as well as a knowledge of the various classes of vehicles, if the congestion features of traffic are to be studied. The points at which the count should be taken are worthy of study, and this study is best made by plotting bands of different colors and widths along the roads of streets where the census has been taken. Work of this kind has an intimate relation to building district restriction plans, and to the city plan generally.

Uniformity in methods of taking and recording censuses and in the assignment of weights, is much needed for comparison in different sections. Some office work can be saved by the use of standardized forms and the writer would suggest that this matter be given attention by the Committee of Standards of this society, and that the co-operation of other engineering societies be sought in making such forms.

In conclusion, the writer would direct attention to the fact that the Traffic Census has a wide application to city work in the selection of pavements, street widening, the removal of encroachments, traffic regulation, fixing values of property, opening of new or extension of old streets, operation of street railroads and busses under franchises, determination of the amount of wear of various kinds of pavement under known weights of travel, regulation of the dimensions, weights, etc., of vehicles, and the determination of a paving policy.

Winter Breakups on New York State Roads.—In connection with the design of pavemnets the New York State Highway Commission made special studies of the present and future requirements of traffic, and of conditions of climate and soil in their relation to highways. These studies have been supplemented by analyses of the inadequacies of past work and of the causes of winter breakups. A survey has been made of every break-up on every State road. Ninety per cent of these break-ups naturally occur on the older roads built prior to 1913. All together they make an appaling total equivalent to 85 miles of 16-ft. pavement.

Effect of Tannic Acid on Cement Action.—Tests are being made by the State Highway Commission of New York to determine the effect of tannic acid on cement action. Much of the sand used in the construction of concrete roads occurs in heavily wooded areas where tannic acid exuded from the hemlock trees, exists in the top soil and may seep to the sand below. The tests are being made on the theory that it is tannic acid that kills the cement action. A number of mortar cubes have been made up with the addition of various percentages of tanning liquor (containing tannic acid as a base). Enough cubes were made to be broken at 7 and 28 days; and at three, six and twelve months.

STREET CLEANING AND REFUSE COLLECTION.

A noteworthy report on the collection and disposal of city wastes was submitted recently to the city officials of Detroit, Mich. This report, while dealing mainly with the street cleaning and refuse collection problems at Detroit, also presents conclusions and suggestions applicable to many other cities. The report was prepared by Raymond W. Parlin, Deputy Commissioner of Street Cleaning of New York City, and H. S. Morse, of the Detroit Bureau of Governmental Research. The following recommendations in the report are of particular interest:

1. That the Department of Street Cleaning and Sanitation be reorganized along geographic lines in order to provide adequate and detailed supervision and to fix responsibility for work done in any particular area.

2. That a planning, inspection and instruction division be created to assist in coordinating work and in standardizing methods of the various branches of the department, to instruct recruits, and to make possible scientific planning to meet demands for extension and readjustment of service.

3. That, in order to make the service more attractive and to increase the efficiency of the personnel: (a) Employes be secured through limited civil service control. (b) Plans be laid for the installation of a pension system. (c) Physical requirements be established for the employment of laborers. (d) Medical assistance be provided for employes. (e) Recruits be employed for a probationary period. (f) Employes' service records be installed. (g) Rates of compensation be standardized and graded so that recognition may be given for superior service. (h) A schedule of promotion be prepared for the information of employes and credit be given for satisfactory records in examinations for promotion. (i) Uniforms and badges be required for all employes while on duty.

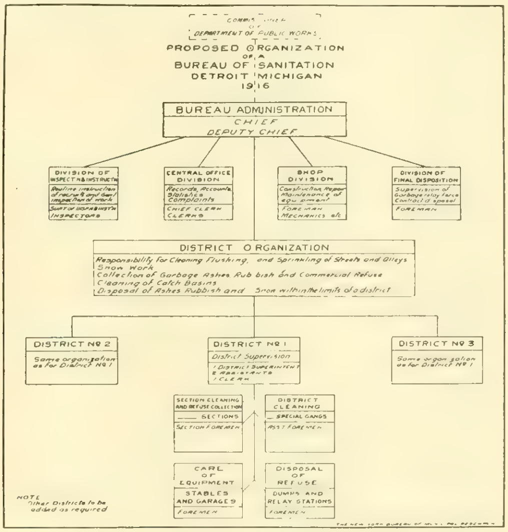

COMMISSIONER
OF
DEPARTMENT OF PUBLIC WORKS
PROPOSED ORGANIZATION
OF A
BUREAU OF SANITATION
DETROIT MICHIGAN
1916
BUREAU ADMINISTRATION
CHIEF
DEPUTY CHIEF
DIVISION OF INSPECT'N & INSTRUCT'N
Routine instruction of recruits and genl inspection of work
SUPT OF INSP'N & INST'N
INSPECTORS
CENTRAL OFFICE DIVISION
Records, Accounts, Statistics, Complaints
CHIEF CLERK
CLERKS
SHOP DIVISION
Construction, Repair, Maintenance of equipment
FOREMAN
MECHANICS etc
DIVISION OF FINAL DISPOSITION
Supervision of Garbage relay force Control of disposal
FOREMAN
DISTRICT ORGANIZATION
Responsibility for Cleaning Flushing, and Sprinkling of Streets and Alleys
Snow Work
Collection of Garbage Ashes Rubbish and Commercial Refuse
Cleaning of Catch Basins
Disposal of Ashes Rubbish and Snow within the limits of a district
DISTRICT Nº 2
Same organization as for District Nº 1
DISTRICT Nº 1
District Supervision
1 DISTRICT SUPERINTENDENT
2 ASSISTANTS
1 CLERK
DISTRICT Nº 3
Same organization as for District Nº 1
SECTION CLEANING AND REFUSE COLLECTION
SECTIONS
SECTION FOREMEN
DISTRICT CLEANING
SPECIAL GANGS
ASST FOREMEN
CARE OF EQUIPMENT
STABLES AND GARAGES
FOREMEN
DISPOSAL OF REFUSE
DUMPS AND RELAY STATIONS
FOREMEN
NOTE
Other Districts to be added as required

Chart of Proposed Organization for Detroit, Mich.

4. That appropriations be made for the city as a whole rather than by wards, in order that the money be expended for service where it is most needed; and that a division of the work of the department be made in accordance with the demands of the service and not along ward lines.

5. That a scientific reporting and cost accounting system be installed, and that a system of control over stores and supplies be developed, to insure a close financial and supervisory control over the work of the department.

6. That more machine flushing and hand patrol service be provided, as these are at present the most effective methods of securing clean streets.

7. That the pickup of material from the gutters after machine cleaning of the streets be more closely coordinated with the machine work, in order that such material be gathered before it is again scattered over the streets.

8. That a special investigation be made to determine whether it is possible to operate street railway flushing machines and abandon street railway sprinkling, since flushing removes the dirt, while sprinkling simply lays the dust temporarily.

9. That citizens contributing to private street sprinkling contracts be encouraged to put their money into additional public flushing, since the practice of sprinkling paved streets where proper flushing is performed is a nuisance rather than a benefit.

10. That the use of sewers for the disposal of snow be increased as a ready and economical means for facilitating such work.

11. That arrangement be made whereby the street railway companies shall clean a portion of the streets of snow, or that such work be done at their expense.

12. That new definitions of the various kinds of refuse be adopted, assuming a separation of refuse into three classes—garbage, ashes, and rubbish—as the first step in economical refuse collection.

13. That larger equipment be provided for the collection of rubbish, in order to reduce the cost of hauling.

14. That consideration be given to city ownership of collection equipment for ashes and rubbish, including both horses and wagons, in order to provide uniformity in equipment and as a means for effecting economies and making possible close control of the collection service.

15. That the work of the sanitary police force, acting under the immediate direction of the Health Department, be expanded to cover

the entire city and that an educational campaign be carried on through co-operation with other interested departments to acquaint the public with its duties in the care of streets and alleys and the treatment of refuse.

The recommended organization is shown in the accompanying chart. Under this plan the city is divided into three districts. This number is used arbitrarily, and it is probable that an intensive study of working conditions will indicate that the number of districts should be increased. This is particularly true because of the recent large increase in the area of the city through annexations.

The organization proposed will reduce the responsibility of a single officer to a point where he can efficiently perform his duty without slighting any part of the city, as is now necessary when one man is obliged to cover the entire city. It should also be possible to assign equipment and men in such a way that there will be no overlapping of the areas for which a particular district superintendent is responsible.

To provide for detailed supervision over the work in various parts of the districts, the present ward system can be copied, with modification of boundaries, and an increase in responsibility be obtained by the addition of activities which do not overlap another ward or section.

The work in each district falls naturally into four groups:

1. The cleaning of streets and the collection of refuse which can be limited to small geographical sections of the district.
2. The work of cleaning streets through the use of special equipment which naturally will cover several sections and must, therefore, be supervised for the district as a whole.
3. The disposal of refuse at dumps or relay stations where the whole district will be served at a few stations.
4. The care of equipment, which includes the stables, garages and yards which serve or lie within a district.

The geographic units or sections referred to under the first group as parts of a district will be similar to the present wards in size, although effective supervision will be facilitated if these units are not so long and narrow as the present wards. Each section should cover an area which would provide all of the routine work which a section foreman and an assistant foreman can effectively supervise, and should be laid out in accordance with the demands of the service and not along arbitrary political lines.

The responsibility of the section foreman should include control over all the cleaning of streets and collection of refuse carried on within the section. Generally speaking, each section should be provided with suitable headquarters for the storage of equipment and control over the force.

The district cleaning will naturally be divided into squads or gangs for machine sweeping and flushing, and over each squad or gang will be placed an assistant foreman. These forces will be responsible for cleaning, whenever it is necessary to cover more than one section with a single gang or piece of apparatus. The co-ordination between the work of the section foreman and district gangs will, therefore, be the duty of the district superintendent under whom both work.

In placing the responsibility for the care of equipment under the distinct superintendent, it is assumed that each district will be provided with equipment from a stable, garage or yard within the district. This is generally necessary if traveling long distances in order to get to the work in the morning and on leaving the work at night are to be avoided. Experience in other cities has indicated that the responsibility for supplying equipment and for doing the work should be placed in the hands of a single individual who is close enough to the work to be able directly to control the situation, and not in the hands of a specialized or centralized long distance control.

As a first step in installing the geographic type of organization in Detroit, it is suggested that as a practical proposition a compromise arrangement be adopted, and that the collection of garbage be operated as a separate function on a city-wide basis, as is at present the case. The function of street cleaning and ash and rubbish collection can then be placed under the geographic organization outlined, and at such time as the organization is running smoothly, it can absorb the function of garbage collection and the necessary readjustments of districts and sectional areas can be made.

The supervision of contracts for the final disposition of refuse can best be controlled centrally rather than by districts. Even if this phase of the work is done by city forces rather than by contract, but through central plants, better control will generally be secured for the city as a whole rather than by districts. On the other hand, district dumps or municipally operated district incinerators can best be handled through district supervision. It is, therefore, suggested that existing contracts for the disposal of refuse be continued under the direct control of the central office. Similarly, garbage relay and loading stations should be controlled from the central office until such time as this portion of the work is performed under a distinctly district plan.

In street cleaning perhaps the most important duty of the superior officers is in planning and laying out the work in advance. The study incident to this requires the best judgment available in the department. To facilitate this work complete physical data in the shape of statistics of previous work, maps, and physical data regarding the geographical divisions of the city should be made available.

As the area and quantity of the work to be supervised increases it becomes more and more difficult for the superintendent or chief administrator of an organization as large as the present street cleaning and sanitation force to get over the ground often enough or thoroughly enough to secure the information necessary for the proper administration of the work. To meet this difficulty, and as an adjunct to the proposed planning division, it is necessary to provide other eyes and minds which will bring to the chief the information which he desires, and these gatherers of information should not be closely associated with the routine work of the department forces. This calls for an inspection force for the chief. The assignment of at least one man to general inspection duties would assist materially in developing an effective administrative control over the field forces. A better plan would be to have as many inspectors as there are districts. Through occasional transfer of these inspectors from one district to another, comparison of methods and results is easily possible and a general improvement and standardization of methods can be obtained.

The advantages of the proposed reorganization plan may be summarized as follows:

1. The elimination of divided responsibility or authority over a single area.
2. A clear definition of the responsibility of the various offices.
3. A concentration of supervision where most required.
4. Relief of the chief of the bureau from details of routine work which now prevent his planning ahead.
5. Better service, with a primary increase in expense, but with eventual decrease in expense for these services.
6. An organization which may be expected, without material change, to meet the growth of the city.

Many county highway engineers seem to be looking for information relating to methods of investigating and developing local gravel deposits. The indications are that the construction plant on many road contracts this year will include a portable or semi-portable outfit for digging and screening gravel and sand. The recent inability of the commercial gravel producers in some sections of the country to obtain enough cars to ship out their orders, coupled with the high price of materials in 1916 and probable higher prices this season, emphasize the economy to be derived from local pit development.

Cook County, Illinois, awarded a contract last week for improving 19 miles of highway. The Commonwealth Improvement Co., Chicago, secured the work at $448,000.

SHEET ASPHALT ON OLD MACADAM BASE.

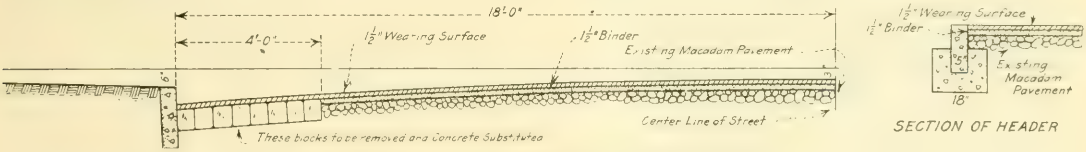
Several eastern cities have adopted the practice of utilizing their old waterbound macadam as a base for a pavement better adapted to modern traffic conditions. New Haven, Conn., last year laid some 98,000 sq. yd. of sheet asphalt on old macadam. The pavement consisted of a 1½-in. binder course and a 1½-in. wearing course, and the average cost was 76 ct. per square yard. A 5-year guarantee was required. Bridgeport, Conn., in 1916 resurfaced some 290,000 sq. yd. of old macadam with Warrenite, at an average cost of $1.69 per square yard. The wearing surface was 2 in. thick and cost $1.20 per square yard; the remainder of the total cost included shaping up of the old macadam and some grading.

Bayonne, N. J., several years ago began resurfacing its old macadam streets with sheet asphalt. At the present time this city has only two macadam streets, and on both of them this paving is comparatively new. The work, last year, comprised the laying of 38,460 sq. yd. of sheet asphalt made up of a 1½-in. binder and a 1½-in. wearing course. The cost was about as follows:

Asphalt surface	$1.25 per square yard
Concrete	$7.50 per cubic yard
Crushed trap rock	$2.00 per cubic yard
New curb	$1.00 per lin. foot
Curb adjusted	$0.25 per lin. foot

The following particulars relate to the methods specified at Bayonne for the readjusting and reshaping of the old macadam pavement so as to form a proper foundation for the new sheet asphalt.

If the old macadam pavement is of the proper grade and contour its surface is thoroughly swept and cleaned of all fine material that may be caked or lying loose as dust on the surface. All low places are cleaned out by picking until only firm macadam remains. The depressions are then filled with clean broken stone and a binder applied and whole thorouoghly wetted and tamped or rolled until firm.



Cross Section of Sheet Asphalt on Old Macadam Base.

Where the surface of the old macadam pavement is not of the proper grade it is spiked or lightly scarified and the surface redressed to the required grade and contour. In all places where the surface of the macadam is lower than the required grade it is brought up by the addition of a layer of freshly crushed trap rock or granite, all of which will pass a 2-in. screen and be retained on a ¾-in. screen. The stone is spread on the roadway immediately after it has been scarified and is then rolled with a self-propelled roller weighing at least 10 tons until the stone does not sink or creep ahead of the roller. Stone screenings or clayey sand or other suitable binding materials are spread uniformly over the surface by shoveling from carts or from piles along the roadway, the object being to very nearly fill the voids of the crushed stone already in place on the surface of the pavement. After this the surface is sprinkled and the rolling continued until the stone is firmly bonded, as in the preparation of a macadam roadway.

In any event, whether the old macadam requires readjusting to bring it to the proper grade or not, it is gone over thoroughly with a steam roller weighing at least 10 tons until it is thoroughly compacted immediately before it is resurfaced with sheet asphalt. All soft spots resulting from the sinking of the macadam foundation into improperly filled trenches or cuts and all places where the macadam is lacking in thickness are dug out to a depth of 5 ft. or less as the engineer may determine and refilled with satisfactory material so as to give a firm and permanent foundation.

A 10-year guarantee is required for the resurfacing work at Bayonne. Hugh H. Mara is Director of Streets and Public Improvements of Bayonne, and Walter L. Clarkson is City Engineer.

GRADES AND ALIGNMENT OF TRUNK ROADS IN PROVINCE OF QUEBEC.

The general principles followed in Quebec in correcting alignments and grades of the trunk roads of the province were outlined by Mr. A. Fraser, Engineer of the Department of Roads, in a paper presented April 11 before the fourth Canadian and International Roads Congress. Notes from this paper follow:

The curves should be planned to afford a sight distance—that is, the greatest distance at which the drivers of two approaching vehicles may see each other's machine—of not less than 250 ft. This is the most important rule.

In the province of Quebec we have adopted the minimum radius of 300 ft. wherever possible without incurring a prohibitive cost. If we have to shorten that radius to 150 ft. and under, we put danger signs at 400 ft. from the B. C. and the E. C.

For the banking of the curves the following rules are advisable: On a curve of between 2,000 and 800 ft. radius, the outer side of the pavement should be 6 in. higher than the inside one; between 800 and 550 ft. radius, 7 in.; between 550 and 400 ft., 8 in.; between 400 and 300 ft., 9 in.; and under 3 ft., 10 in.

When a curve occurs on an ascent, the grade at that place must be diminished in order to compensate for the additional resistance of the curve. When it is necessary to make a radius of curvature less than 300 ft., we usually follow the principle of reducing the grade on the curve at the rate of 1 per cent for every 50 ft. that the radius has to be reduced, so that where we are locating a 5 per cent grade and have to put in a curve with 200 ft. radius we give a 3 per cent grade. As a rule, there ought to be a tangent of about 100 ft. between two curves.

The road on each side of an obstacle should be straight on a length of at least 50 ft. when there is a possibility of doing so without incurring prohibitive expenses.

Do not overestimate the advantage of straightness. The curved road around a hill is often no longer than the straight road over it. In addition, a more or less sinuous course is an advantage from a maintenance standpoint, as on a winding road the wheel traffic has a tendency to spread over the entire surface. Carry the road along the southern or western slope of ridges, if possible, so that it may be less exposed to storms and dry out more quickly after heavy rains and the melting of snow.

The difference in the length between a straight road and one which is slightly curved is very small. On the Montreal-Quebec Road we have eliminated all the bad curves wherever possible, and through that fact we have reduced the first 50 miles of roads from Montreal by only 400 ft. As a matter of fact, we generaly follow the line of the old roads as long as there is no bad curve and no danger for the automobile traffic.

The maximum grade on our trunk roads is 5 per cent, and the exceptions to this rule are very few. It has been demonstrated by careful observers that a horse, for a limited period of time, can exert 40 per cent of his weight in tractive force; then, for a short distance, it is better to place a 6 or 7 per cent grade over a limited distance than to make a deep and expensive cut.

In the province of Quebec we generally make the grade follow the natural undulations of the ground as long as we remain below the maximum grade and the sight distance is at least 250 ft. The expenses incurred in making a level or nearly level road would not be warranted by the traffic anticipated for many years to come. Farmers are satisfied with a maximum grade of 5 per cent, and this grade meets with no objection from owners of motor vehicles of any type.

Some experiments made by Mr. H. Kerr Thomas and Mr. O. Ferguson of Buffalo, N. Y., for the Pierce-Arrow Motor Co. show that the class and kind of surface exert more influence upon the motor vehicle than the per cent of grade and that it requires practically the same tractive force on a 1 per cent grade in sand and loose stone to handle the same load as it does on a 27 per cent grade on concrete.

A farmer or teamster would rather go up a mile of 5 per cent grade on a good alignment than a mile and a half of curves on a 2 or 3 per cent grade, with a possible surprise party awaiting him at every turn of the road. It is generally admitted that an automobile of ordinary power can operate on high gear wherever the grades do not exceed 5 per cent.

Grades as high as 10 per cent or over must be avoided at all cost in our country because they are very dangerous, both for horse and motor traffic, in frozen and icy weather. Deep cuts must be avoided as much as possible on account of the snow and the resulting difficulties for traffic in winter and spring.

There is occasionally a road upon which the summit of two intersecting grades is a source of danger, because the drivers of cars which happen to meet just at the top cannot see each other until just before they meet. This meeting point of two grades should be rounded off by a vertical curve so as to insure a sight distance of at least 250 ft.

BUSINESS AND MOTOR TRANSPORTATION.

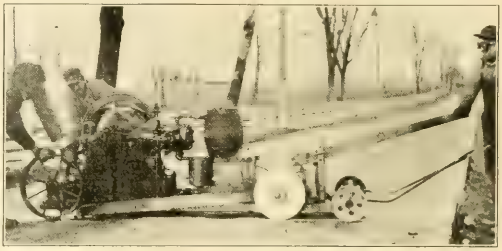
Men engaged in merchandising are interested in roads because of the facilities they afford for the economical and quick delivery of goods and the consequent opportunities offered for the extension and development of trade. Well-improved roads provide a means of transportation and communication available and satisfactory at all seasons of the year, and trade is therefore more continuous and more reliable. Motor truck transportation has, moreover, opened up new avenues of trade.

Motor truck transportation over good roads affects tradesmen in the increased area over which business can be done, the greater regularity and quickness of delivery and the improved facilities for handling a rush of business. From 15 to 20 miles a day is the usual limit of travel of a 3-horse team employed in mercantile service, while a motor truck frequently covers from 50 to 75 miles in the same length of time and carries a much larger load. The difference in the ton-mile cost of hauling is marked. Between stores in large towns and small shops in villages from 20 to 30 miles distant it is often operated as a heavy freight vehicle. The ton-mile cost of transportation is correspondingly decreased. Extremes of weather have small effect on motors, as compared with horses, and regularity of service is therefore enhanced. Also well-maintained speed of travel from 8 to 15 miles per hour increases the quickness of delivery. In a rush of business motor trucks can be operated almost continuously night and day, thereby covering for suddenly increased business with the equipment ordinarily employed. A smooth, hard road surface is, however, essential to the successful operation of motor trucks, and it is readily seen that merchandising is vitally affected in this respect by the condition of the roads.

The suburbs of towns are in effect extended by motor transportation and good roads. Men employed in towns live in the country and travel to and fro and have their supplies delivered by motor. The pleasure vehicles of town dwellers penetrate further into the rural districts, bringing townsmen in contact with countrymen in the country, thereby improving social relations. At the same time this business of the agriculturist becomes better understood by the tradesmen from whom he buys his supplies and to whom he frequently sells his produce, and the credit relations between them are improved.

DEVICE FOR CUTTING DOWN HIGH JOINT PLATES ON CONCRETE ROADS.

In concrete road construction it sometimes happens, owing to careless workmanship, that the steel protection plates at the joints project above the surface of the pavement. Cutting down these high places is a rather difficult problem. Some work of this kind was done recently on the Dixie Highway in Kenyon County, Kentucky, under the direction of M. D. Ross, Division Engineer, State Department of Public Roads. For this work the portable grinding machine illustrated below proved very satisfactory and economical. This machine consists of a 6-H.P. gasoline engine, with 24-in. drive wheel belted to a 4-in. pulley, carrying a 15x3-in. emery wheel. The outfit is mounted on a 4-wheel frame, which is underslung from the rear axle and which is supported at the front by wheels much smaller. The center of gravity of the outfit is low and accordingly it can be guided easily by a tongue attached to the front. By means of a lever the emery wheel can be forced down against the plate with very little pressure being required for heavy grinding. Water is supplied to the wheel from a keg on the frame.


Portable Grinding Machine Cutting Down High Protection Plates.

The complete outfit weighs about 1,000 lb. and can be handled easily by two men. In the Kentucky work it has been found in grinding down the joints where it is necessary to cut the concrete, that it is much better and faster to use a cold chisel for the concrete and then grind down the plate with the emery wheel. Some 25 joints were cut down on the Dixie Highway. This was accomplished in about six days with two and sometimes three men working.

Causes of Failure in Concrete Test Cubes.—Tests made last year by the New York State Highway Commission of 6-in. concrete cubes cast in the field and tested at 28 days gave the following results:

Mix.	Kind of coarse aggregate	Compression lbs. per sq. in.	No. of cubes.
1-1½-3	Stone and gravel (average of all cubes)	3,370	504
1-1½-3	Stone	3,380	445
1-1½-3	Gravel	3,080	48
1-2½-5	Stone	2,180	54
1-2½-5	Gravel	2,040	82
1-2½-5	Slag	2,060	26
1-3-4½	Slag	2,345	29

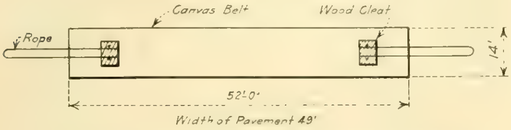
Of all cubes submitted for test, 13.25 per cent showed a compression below the average for the class of concrete they represented, allowance being made for cubes cast and cured during cold weather. All cubes showing compression below the average were examined for defects which are tabulated as follows:

	Per cent. 1916.	Per cent. 1915.
Coarse aggregate coated	61.9	35.0
Fine aggregate containing an excess of loam or made up of excessively fine grained sand	25.7	43.9
Coarse aggregate of poor quality	6.2	8.2
Poor manipulation in making cubes	6.2	16.9

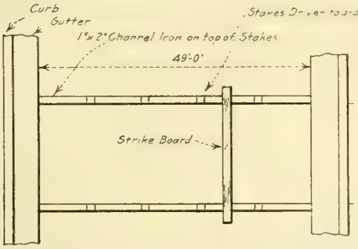
Daily Diary on Highway Construction.—The State Highway Commission of New York last year installed the use of the daily diary on every piece of construction work. In two or three cases that have been in dispute these records already have become a valuable factor in the settlement. These diaries are to be returned to the head office with the final estimate and will make a part of the complete record for the road, so that should a case develop in the Court of Claims there will be full information for those handling the State's defense even though the men employed on the job are not available.

BELT METHOD EMPLOYED ON 49-FT. WIDE CONCRETE PAVEMENT.

The belt method of finishing concrete pavement has been employed by the city of Ogden, Utah, with very satisfactory results on streets up to 49 ft. in width. This year it is proposed to use the same method on streets having a pavement width as high as 55 ft. The accompanying sketch shows the method employed by the city in striking off the concrete pavement on a wide street. For the finishing a canvas belt arranged as shown in the sketch is used. Before buying a rubber or canvas belt experiments were conducted with a strip of ordinary burlap, 2 ft. wide and 55 ft. long. With this a very good finish was given to the surface. All concrete pavements in the city are now finished by the belt method and this plan has been found to be very economical and satisfactory. Joseph M. Tracy is City Engineer of Ogden, Utah.



SKETCH OF BELT USED IN FINISHING CONCRETE PAVEMT



SKETCH SHOWING METHOD OF STRIKING OFF CONCRETE PAVEMENT ON WIDE STREETS

Sketches Showing Belt for Finishing Concrete Pavement and Method of Striking Off Concrete on Wide Streets.

METHOD OF HASTENING MELTING OF SNOW ON MOUNTAIN ROADS.

The sprinkling of sand or dirt on the surface of heavy drifts on the mountain roads of California has been found to be very effective in hastening the melting of the snow. According to the circular of instructions to the superintendents of all State roads issued by H. H. Bell, Road Engineer of the State Department of Engineering, the sand or dirt should be applied at the earliest possible date and in sufficient quantity to thoroughly color the surface. Care should be taken not to apply enough material to form a crust over the surface. Other methods of handling the snow are outlined as follows:

When drifts are exceedingly deep light blasting is permissible. This blasting loosens and opens up the snow in the drifts thereby permitting the circulation of air through the snow, which greatly increases the rate of melting. The blasting should be done in each case prior to sanding the surface of the drift. On a number of the divisions it is the practice to drop these blasts into holes made in the drift with an iron or steel bar, the frequency and size of the blasts depending upon the depth and character of the snow. Blasts consisting of from ½ stick to a full stick of ⅞x8-in. 40 per cent powder have been found to be very effective for this work.

There are places where a grader may be used to advantage in clearing the roads of snow. On several of the divisions discs have been used to advantage to break up the snow and hasten its melting.

CONVICT LABOR ON STATE ROAD WORK IN VIRGINIA.

For the past 10 years Virginia has been employing convicts on road work under the direction of the State Highway Commissioner. The plan has proved so successful that the state legislature at its last session appropriated $200,000 from the general funds and $50,000 in jail fees for this division of the Highway Department. The methods employed in Virginia in handling this convict labor were discussed by Mr. George P. Coleman, State Highway Commissioner, in an address at the recent annual convention of the Florida Good Roads Association, from which the following notes are abstracted:

The camps vary in size from 35 to 100 men, according to the character of the work to be undertaken. A sergeant with from three to five guards is selected from a list furnished the superintendent of the penitentiary by the Highway Commissioner, who has the right to require their discharge at any time should their services prove unsatisfactory. The sergeant receives from $600 to $900 and board per annum; the guards, from $300 to $420 and board per annum.

The camp is composed of three buildings—a sergeant's and guards' house, a cell house and a dining house. The sergeant's and guards' house consists of two rooms and is 15x36 ft. in size. The sergeant's room is also used as an office and armory. The cell house for the men is 20x72 ft., with a row of bunks down each side and a passageway through the center. It is heated in winter by three stoves. The dining house, 20x56 ft., is divided into a dining room for the men, a dining room for the sergeant and guards, a storeroom for supplies and the kitchen.

These buildings are of the knock-down type. Corrugated iron is used for roofing and 10- to 12-oz. duck for sides. All of the woodwork where possible is either bolted or screwed together. When the camps are sent out they have all the necessary arms, cooking utensils, bedding, clothing and sufficient general supplies to last about 60 days. Exclusive of clothing and provisions, these camps cost $1,840.

Camp sites are selected with great care, particularly with a view to a plentiful supply of pure water and proper drainage; also that the walk to and from work may be reduced to a minimum. This, in the most extreme cases, should not exceed 2½ miles. The cooking and washing, and in fact all work about the camp, is done by prisoners under guard. One man is required for this service for every twelve men in the camp. These are taken from the men who are not capable of doing the heavier classes of road work. The men are divided into gangs of from 8 to 15 and are used in grading, quarrying, etc., each gang being in charge of a guard or foreman. The system of working prisoners under guard is generally followed in the southern states. In the northern and western states the men for road work are selected from the entire convict body and only the better class are used, and frequently used without guards. The experience in Virginia is that a certain number of trusties is required in each camp, the total for the whole state running to about 36 per cent during the past twelve months.

The road work proper is in charge of an engineer or superintendent appointed by the Highway Commissioner. He receives from $900 to $1,500 per annum, but it is hoped to have this increased to a maximum of $2,100 by the next General Assembly.

The prisoners are trained in all classes of road work. Trusties are made into rollermen, firemen, blacksmiths, carpenters, drill runners, concrete men, etc., the trusties being selected by the sergeant from the better class of prisoners. The state convict road force is composed of all male convicts who are considered safe by the superintendent of the penitentiary and all jail men over 16 years of age. This force, when placed on a county road or in a county quarry, is clothed, fed, guarded and transported by the state and placed on the road each morning free of all cost and expense to the county. Prisoners working on road force have, for good behavior, a reduction of ten days per month from the time for which they were sentenced.

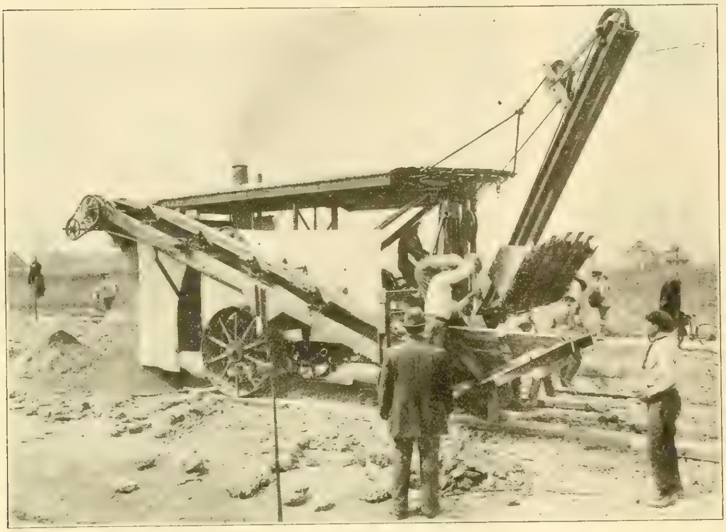
The men cost a little over 57 ct. per 10-hour working day, which is divided about as follows:

	ct.
Provisions	22.8
Clothing	5.7
Salaries	19.5
Mileage	1.2
All other expenses	8.2

During the first two years this cost was a little over 72 ct.

PORTABLE SCREENING MACHINE FOR UTILIZING OLD PAVING MATERIAL.

A portable screening machine attached to a steam shovel is being employed by the German Rock Asphalt Co., Inc., Buffalo, N. Y., in connection with a street improvement contract at Buffalo. The work includes the removal of an old natural cement concrete base and the relaying of a new Portland cement concrete base. The stone from the old concrete is to be utilized in the new base.



Portable Screening Machine Used by German Rock Asphalt Co., for Utilizing Material from Old Pavement Base.

The machine is attached to a Model 3 Keystone traction shovel as shown in the accompanying illustration.

The shovel loads into a hopper feeding onto a 20-in. belt, which carries the material into a circular screen. The machine as used on the present job has a capacity of upwards of 200 cu. yd. per day and it takes the place of 60 or 70 men screening by hand, which has heretofore been the practice of the German Rock Asphalt Co.

It is the intention on other machines to add a bin to catch the screenings, thus avoiding the time taken to shovel waste materials from the ground.

The machine was invented by Mr. Henry Weigen of Buffalo. He believes that it will also answer as a combination washer by attaching a washing device to the screen. In this way the stone could be saved from old macadam and loamy materials. It also could be used to feed a concrete mixer, in which event the mixer could be attached as a trailer and the concrete materials picked up by the shovel and dumped into a hopper feeding the mixer.

The State Highway Commissioner of Ohio opens bids at Columbus, O., on June 14 for the improvement of 159 miles of road. The total estimated cost is $1,042,000 and the work is located in 41 counties.

STATE HIGHWAY CONSTRUCTION IN NEW YORK IN 1916.

The mileage of State highway completed in New York in 1916 was greatly below that of the previous year. The figures, according to an advance copy of the annual report of H. Eltinge Breed, First Deputy Highway Commissioner, were as follows:

	1915. Miles.	1916. Miles.
Actually completed and accepted during the year	758.61	514.68
New contracts let during year	983.78	635.87
There were officially under contract Dec. 31st	1,310.98	1,435.65
Physically completed, but not accepted, estimated, Dec. 31st	532.00	530.00

The mileage of each type put under contract in 1915 and in 1916 was as follows:

	1915.	1916.
Waterbound macadam	352.56	34.83
Waterbound macadam surface application	148.28	260.93
Bituminous macadam (penetration method)	336.06	200.74
Bituminous macadam (mixing method)	2.20	1.76
Brick	29.52	12.52
Cement concrete	100.51	123.93
Miscellaneous	14.65	1.16
Total	983.78	635.87

The decrease in the amount of work accomplished is ascribed to the following factors: The scarcity of labor; the lack of supplies; the reluctance of contractors to undertake work with materials and workmen constantly increasing in cost, and growing uncertain at any price; the inefficiency of such labor as could be obtained; and the caution of bonding companies in assuring new work.

The accompanying tabulations, rearranged from Mr. Breed's report, show the average costs of road work and materials for 1914, 1915, 1916. Table 1 shows the average cost per mile of 16-26-ft. highways exclusive of engineering and advertising. These prices are computed on the prices bid on awarded contracts so that they exactly represent conditions as viewed by the contractors, many of whom, however, in making these bids, did not allow sufficiently for the rising prices of labor and materials. That they did not, is best evidenced by their financial failure.

Table II shows relative prices of brick, cement and broken stone for the years 1914, 1915 and 1916, with the percentage of increase. This does not show an increase to so large an extent as the bid prices, for in many cases much of this material was sold under contracts which were made early in the year.

TABLE I.—AVERAGE COST PER MILE OF 16 FT.-26 FT., NEW YORK STATE HIGHWAY.

	Average cost, 1914.	Average cost, 1915.	Average cost, 1916.	Per cent decrease, 1915-1914.	Per cent increase, 1916-1915.	Per cent increase, 1916-1914.
Waterbound macadam	$11,049	$10,023	$11,227	9.3	12	1.6
Waterbound, surface application	11,095	9,869	11,826	11	19.8	6.6
Bituminous macadam	13,339	11,005	13,725	17.5	24.7	2.9
Concrete	13,518	13,418	14,995	0.7	11.8	10.9
Brick	25,323	24,217	27,739	4.4	14.5	9.5

TABLE II.—PRICES OF ROAD BUILDING MATERIALS.

	Prevailing prices, 1914.	Prevailing prices, 1915.	Prevailing prices, 1916.	Per cent decrease, 1915-1914.	Per cent increase, 1916-1915.	Per cent increase, 1916-1914.
Brick	$0.88*	$0.88*	$1.02*	....	15.9	....
¾-in. stone	1.09	.96	1.00	11.9	4.2	8.3†
1½-in. stone	.99	.88	.90	11.1	2.3	9.1†
Cement	1.58	1.36	1.72	13.9	26.5	8.9

*Per sq. yd. f. o. b. cars. †Decrease.

PRACTICE OF NEW YORK STATE HIGHWAY COMMISSION IN CONSTRUCTION OF CONCRETE PAVEMENT.[*]

Grades.—Grades are still treated differently in different sections of the country. Our original practice was not to exceed 5 per cent, but today we are building them as high as 8 per cent under certain conditions. Grade seems to be limited only by the ability of the wet concrete to run during the process of construction, by the character of the mix and the kind of traffic to use it. Even on a steep grade, the use of a coarse sand prevents the roads from being slippery; and I believe that brooming of the surface facilitates the traction hold of all classes of traffic. Floating should be at a minimum as this operation brings the finer particles to the surface which gives a smooth top.

Width.—Most of the roads we have been building in New York State are 16 ft. in width. This is because when the money was appropriated to build our system it was on the basis of approximately $13,000 per mile. That was a low figure even at the time, in 1912; at present it is obviously impossible to complete the system as planned then. It would be far better, and ultimately more economical, if we had sufficient funds to build them 18 ft. in width. For two lines of traffic on a concrete road 18 ft. should be the minimum width; for three lines, 24 ft.

Square-Cornered Edges.—In design the edge of the concrete slab next to the shoulder should be vertical and square cornered. Then if it becomes necessary to reinforce the shoulder with road metal a good joint can be made; and, more important still, if additional widening is required, it can be accomplished with a longitudinal joint of minimum size. We have very satisfactorily widened some miles of concrete roads built throughout the State in accordance with this design by adding 4 or more feet to one or both sides of the pavement.

Where the soil for the shoulders is unstable we are entrenching it with crushed stone or gravel 4 to 6 in. deep and 1½ to 3 ft. wide. Although this gives good results and makes for additional safety, still, if much traffic must be turned onto them the maintenance cost of these stone and gravel shoulders is so high as to justify the additional first cost of a wider pavement.

Accidents on 16-ft. Roads.—In order to obviate the danger of accidents on our 16-ft. roads, we have been widening or mooning out the curves, so that in some cases for those of small radius at the center the actual curve is as much as 22 to 24 ft. wide. We have also considered it good practice to give the outside of these curves a superelevation in order to make easier the steering of a car, to lessen the likelihood of skidding, and to insure greater safety in taking these curves at speed.

The Mix.—The mix should be proportioned in such a manner as to give the greatest density. With our requirements for materials we have found that the proportions of 1-1½-3 most nearly do this. Our specifications provide that the concrete shall be mixed in the proportions of one volume of cement to 4½ volumes of sand and broken stone or gravel, and the proportions of fine and coarse aggregate are varied slightly as a result of field void tests so that the greatest density is obtained. Should the size or character of the materials change there would be a corresponding change in the proportioning of the mixture.

The coarse aggregate should consist of a well mixed product of clean No. 1, No. 2 and No. 3 stone or gravel.

No. 1 size is that retained on ⅜-in. circular and passing a ⅝-in. circular screen.

No. 2 size is that retained on ⅝-in. circular and passing a 1½-in. circular screen.

No. 3 size is that retained on 1½-in. circular and passing a 2¾-in. circular screen.

It is provided, however, that not more than 25 per cent of the total shall be No. 1 size, the proportion being so graded as to give a minimum of voids.

We allow, as our maximum size, stone that will pass a 2¾-in. ring, whereas most specifications permit only 1½-in. stone as a maximum. This may seem radical, but our reason for the increase in size is that we get equally as good if not better results from the larger stone, and at a cost decidedly lessened by our using more nearly the product of the crusher. Especially is the price to be considered on contracts where the local supply is crushed on the ground, as is the case in most of our work. If you desire economy, this change is worthy of your consideration. We save 15 per cent in crushing costs by this use of stone larger than the previously accepted standards.

Construction.—An exact subgrade is necessary to save the concrete that would be wasted in evening up inequalities in the foundation. The extra time and attention spent on getting an exact subgrade will be well repaid.

The materials should be placed well in advance of the laying, so that when the mixer has once commenced operations the work may be continuous. If the road is being constructed of imported materials the use of a stock pile to prevent shortage will materially reduce the loss from delays in operation. In order that the minimum amount of work may be done in taking materials from the subgrade and placing them in the mixer, it is advisable that the superintendent and foreman should each have a list of the amounts to be distributed for every hundred feet. A little attention to this detail will save largely in the item of labor.

Materials should be rejected before they are unloaded to come on the work. As good quality is essential in both sand and stone, both these materials should be checked up from day to day in order to secure the best results.

Attention should be given to the screed or strike board. This should be heavy enough to screed the concrete properly, and it should be cut to conform to the crown of the road. It should be provided with handles and be shod with a steel angle-iron bent to the shape of the roadway. Wooden floats should be provided for doing the necessary floating, and the float to be used as a joint should he split in such a manner that it will ride over the joint smoothly and will cover an area of at least 1 ft. on either side of the joint. Steel forms, while more costly than those of wood, are far more economical in the long run and pay for themselves in a short time.

Measuring barrows should be of such a type that their measurement can be regulated by the bolting of boards across the rear part of the barrows to make the quantities adjustable. Forks should be provided for taking the stone from the subgrade in order to eliminate the dirt.

To insure a sufficient supply of water a pipe line should be installed, for although tank supply may amply provide the mixer, it can scarcely take care of that and attend to sprinkling too.

The concrete road presents a good problem for the application of labor saving devices in the handling of materials and many different installations have shown reasonable cost reductions. The industrial railroad has played a large part in this.

The forms should be placed in such a way as to give them stability and they should above all be tight. The subgrade should be kept drenched with water immediately ahead of the laying of the concrete.

An ordinary concrete force in operation on a 16-ft. road is comprised of from 32 to 35 men doing all branhes of the work and it is quite often necessary to rearrange the gang so that the best results may be secured in keeping the mixer in continuous operation.

Suitable measuring tanks should be provided so that the amount of water may be such as to make the separate batches of the same consistency, the ideal consistency of concrete being where it will just settle and will not run. This is very important as the density of the resultant concrete is dependent upon it; if too wet the materials will run on the grades.

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[*] Abstract of a paper presented at the Boston meeting of the American Road Builders' Association by H. Eltinge Breed, First Deputy Commissioner, in charge of construction for New York State Highway Commission.

The concrete should be well spaded and kept high above the screed or strike board on the mixer side. Tamping should not be allowed. In screeding, the screed should be slowly pulled back and forth, advancing it slowly with each operation. When approaching a joint the screed should be brought up to the joint and carried back in order that the surface may be uniform. No more floating than is absolutely necessary should be resorted to as the primary object is to have the wear on the surface taken by the stone, and not by the thin mortar layer produced by floating.

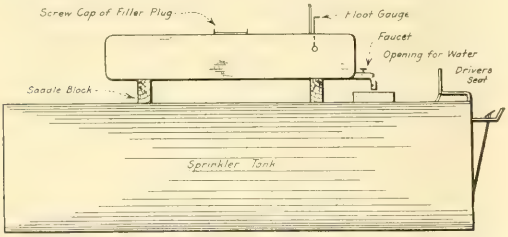
Placing of joints should always be perpendicular to the surface of the pavement. If they are not, in subsequent expansion there is often riding of the slabs. In many instances it may be necessary to stiffen up the consistency of the concrete in order that the screeding on grades will not give a ridgy effect. If possible, all work on grades of over 4 per cent should be worked up hill. The cement factor should be taken daily and reported to the division engineer.

Curing properly is as necessary as good construction, for upon this depends to a large extent the strength of the resultant concrete. Sprinkling should be commenced as soon as the surface will not pit and a cover of 2 in., at least, of sand or loam should be spread over the surface. This cover should be kept saturated with water for 10 days. Care should be taken, however, not to place cover until the concrete is sufficiently firm to withstand the impact caused by placing. Sprinkling should be done in such a manner as not to wash the cover from the surface. When the temperature gets below 50° F. in the middle of the day, sprinkling and cover may be omitted. When concrete is laid in cold weather its curing period should be lengthened as low temperature retards its gain in strength. Work done in November should be allowed to cure from four to six weeks.

APPLYING DISINFECTANT IN STREET SPRINKLING.

In connection with its street sprinkling the city of Live Oak, Fla., applies a disinfectant to the streets. The appliance for introducing this disinfectant into the water was devised by Mr. L. T. Morgan, City Engineer.

On top of the water tank of the street sprinkler a 10-gal. galvanized iron tank (one of larger capacity would be better) is mounted by means of two saddle blocks. These blocks are cut from 2-in. x 10-in. plank and are placed vertically and crosswise of the sprinkler tank, the bottom edges being sawed to fit the top of the sprinkler tank and the top edges sawed to fit bottom of the small tank. At the end of the tank there is a faucet for drawing out the disinfectant.



Device for Applying Disinfectant in Street Sprinkling.

The tank is so placed that the faucet discharges into the opening in the top of the sprinkler tank through which it is filled with water. The tank is also fitted with a gage so marked as to show the proper amount of disinfectant to charge the tank of water. Then as the driver fills his tank with water he opens the faucet, allowing the correct amount of disinfectant to flow in with the water, and as the water goes in with pressure it stirs or causes the disinfectant to be thoroughly mixed. Knowing the required amount necessary for a gallon of water the gage can be so set as to get just enough disinfectant each time.

SUBJECTS FOR CIVIL ENGINEERING COURSES TO QUALIFY GRADUATES FOR HIGHWAY ENGINEERING.*

The development of the construction of highways in the United States during the past decade has created a demand for broadly trained highway engineers which far exceeds the supply. The present situation is readily grasped when the following facts are analyzed. According to a statement recently issued by the office of the Secretary of Agriculture of the United States "during the past 12 years the annual expenditures on the rural roads and bridges in the United States has increased from about $80,000,000 to about $282,000,000, or an increase of more than 250 per cent. The public roads of the United States, outside the limits of incorporated towns and cities, have at the present time a total length of about 2,425,000 miles, of which 277,000 miles or 11.3 per cent are improved with some form of surfacing. The mileage of surfaced roads is increasing at the rate of about 16,000 miles per annum." Of the 48 states, 44 have highway departments. There are over 3,000 counties in the various states. The county and township highway work is in the hands of 100,000 highway officials. The 12,000 municipalities in the United States each have from 1 to 20 officials in charge of departments whose work pertains to highways. In the states, counties, and towns certainly not over 5 per cent of the highway officials possess the training and experience necessary to efficiently and economically perform the duties imposed upon them. With reference to municipalities, the percentage may be increased to 25.

The public demand for efficient instruction in highway engineering is well expressed in the following quotation from one of the publications of the National Automobile Chamber of Commerce: "It is desirable that as many institutions as possible should offer highway courses in the senior year, of not less than three hours a week for the full collegiate year. Graduates from these institutions, who have the executive ability and other qualities that would fit them for the higher administrative positions, can thus pursue their studies in highway engineering in postgraduate courses offered in a limited number of universities equipped with properly qualified instructors, apparatus, etc. Before taking such an advanced course, however, students should have a year or more of actual experience in road building; otherwise they will be unable to grasp the significance of all the lectures and studies."

The consensus of opinion of eminent highway engineers to the effect that more time should be devoted to highway engineering in civil engineering courses was well expressed in 1911 before the Society for the Promotion of Engineering Education by the late Harold Parker, former chairman of the Massachusetts Highway Commission, who said: "I have found in my own experience that, although I could get civil engineers well fitted for all the work ordinarily required of a civil engineer, I could not obtain a man fitted for highway work until years of practice in the field had rendered him efficient and useful. This has been the experience of practically every commissioner who has had charge of state work and of those who have the street departments in a municipality under their charge as well."

It is evident that educators in American institutions of learning are rapidly appreciating the necessity of rearranging civil engineering courses to meet the present needs of the profession. For example, in 1909 only 50 per cent of the institutions in the United States included a course in highway engineering in their civil engineering curricula, while in 1912 the percentage had increased to 85, and today it is with difficulty that a civil engineering course, in a first-class institution can be found which does not include, either as a requirement or an elective, a course in highway engineering.

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*An article by Prof. Arthur H. Blanchard, Consulting Highway Engineer, New York City, in the April Bulletin for the Society for Promotion of Engineering Education.

As the other papers presented in this symposium comprehensively discuss the essentials of the educational training of highway engineers and the requisite qualifications of engineers who are candidates for positions with state, county, and municipal highway departments, contractors' organizations, and in other fields open to specialists in this branch of engineering, this paper will be primarily devoted to a statement covering the subjects which should be included in a 4-year civil engineering curriculum in order to qualify graduates to enter the field of highway engineering. The time assigned to highway engineering, per se, is based on the fundamental principle stated as follows by Dean F. E. Turneaure: "It is our belief that highway engineering should be given relatively about the same emphasis in a college course as other branches of civil engineering."

General Subjects: English Composition (2 years, 3 hours per week); Public Speaking; English Literature; Fundamentals of French and German Grammar and Translation (3 hours for 1 semester for each language); Economics; Social and Political Science; Philosophy; Physical and Military Training.

Science: Algebra; Plane and Spherical Trigonometry; Plane, Solid Analytical and Descriptive Geometry; Elements of Calculus; Free-hand, Mechanical and Topographical Drawing; Physics and Chemistry (lectures and laboratory); Geology and Astronomy (lectures and field work).

General Engineering: Applied Mechanics; Elements of Electrical and Mechanical Engineering; Engineering Jurisprudence.

Civil Engineering: Plane, Topographical and Railroad Surveying; Railroad Engineering; Strength of Materials (lectures and laboratory); Foundations; Elements of Structures and Structural Design; Elements of Sanitary and Hydraulic Engineering.

Highway Engineering: (3 hours per week for 1 collegiate year in every civil engineering course, and 3 to 6 hours additional per week for one semester as elective in certain institutions, dependent upon local requirements and conditions.) The following subjects should be included in a highway engineering course: Historical Development of Highways (exemplifying interrelationship between social progress and improvement of methods of transportation and travel); Preliminary Investigations, Surveying and Mapping peculiar to Highway Engineering; Traffic (including types, census and effects upon road and pavement surfaces and foundations); Design of Highways (including grades, cross-sections, drainage and foundation problems, estimating quantities and cost data); Materials of Construction (lectures and demonstration laboratory work with soil, sands, gravels, rocks, bricks, woods, cements, concretes, and bituminous materials); Construction, Maintenance and Preparation of Specifications (covering earth, sand-clay, gravel and broken stone roads; bituminous surfaces on gravel and broken stone roads; bituminous macadam, bituminous concrete, asphalt block, sheet asphalt, wood block, stone block, brick, and cement-concrete pavements); Street Cleaning and Snow Removal; Car Tracks, Pipe Systems, Curbs and Gutters; Highway Structures (including design, materials, and construction of bridges, culverts and retaining walls); Comparison of Roads and Pavements (including consideration of durability, sanitary qualities, noiselessness, slipperiness, resistance to traffic, annual cost, records and cost data forms); Highway Economics, Administration and Legislation.

In conclusion it is recommended that highway engineering courses in civil engineering curricula be given by teachers who have had experience in the construction and maintenance of highways. It is generally recognized that the most efficient instructors are those who have had a combination of experience in teaching and practice in the branches of engineering assigned to them. The rapid development of the art and science of highway engineering makes this fundamental principle particularly applicable to the selection of instructors in this subject.

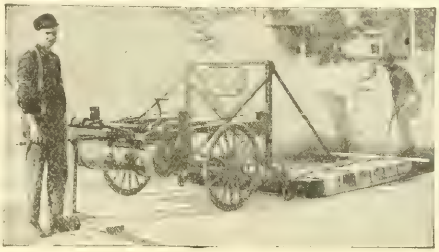
THE PLUTO ASPHALT SURFACE HEATER.

The "Pluto" Asphalt Surface Heater is a comparatively inexpensive machine which is producing satisfactory results in street repair and maintenance work in several municipalities, notably Detroit, Mich.

The method of repairing asphalt pavements when this machine is used requires the heating of only ½-in. to 1-in. of the top surface of the pavement. This is accomplished in from 5 to 7 minutes. This is quite a contrast to the pick-and-bar method which requires the removal of the asphalt to a depth of 2 in. or more. The use of this machine means a saving in new asphalt, saving in labor of handling and teaming spent asphalt, as well as the labor and handling of new asphalt for re-fill.

The accompanying illustration of this surface heater in operation shows how the pan, containing six Chausse kerosene burners each throwing a flame 6 ft. in length, is lowered close to the surface so that the flame is controlled entirely within the pan. The burners are started either by an auxiliary hand torch or by stuffing the burner chimney with paper and spraying this with kerosene. One of the ordinary laborers from the re-surfacing gang can start and operate the machine and can be removing spent asphalt while the machine is operating on new surface. The fuel consumed will approximate 6 gal. of kerosene per hour.

One of the main features of this machine is the Chausse burner. The kerosene is burned as a gas or vapor and not as a spray. Thus an absolutely clean joint is produced between the old bed of asphalt and the new asphalt applied and no oil film is present to interfere with this joint.



Pluto Asphalt Surface Heater in Operation at Detroit

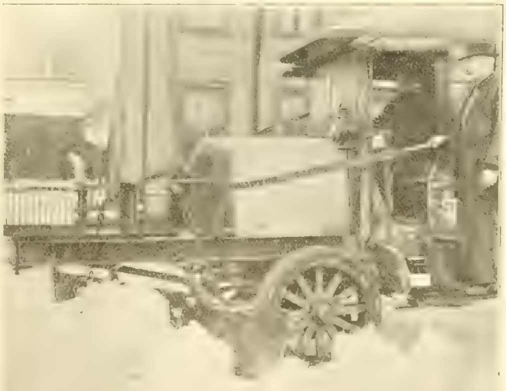
The frame of the machine is strongly built of steel with a channel iron main framework and by a system of gears folds up like a jackknife. The two pivot wheels balance it so that it can be moved around in position by one man or for a long haul it can be trailed behind an automobile.

Another style of "Pluto," designed to operate close to the street car tracks without interfering with traffic, has a side heater-pan. An even smaller type, equipped with two burners, is made for removing narrow ruts.

These machines have been placed on the market by the Alger Supply Co., Peoples Gas Bldg., Chicago.

MOTOR TRUCK SNOW PLOW.

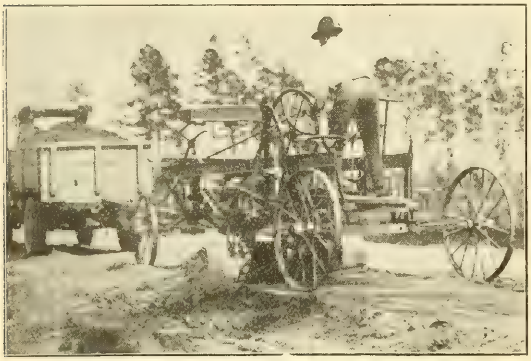
A snow plow attached to a motor truck is used by the Department of Public Works of Detroit, Mich., for removing snow from roadways. The method of operation is shown quite plainly in the accompanying illustration. In the summer time, the plow is removed, and the truck, a Packard, is used to carry hot asphalt from the city's plant.



Snow Plow Attached to Motor Truck, Used by D. P. W. of Detroit.

DUPLEX TRUCK IN ROAD WORK.

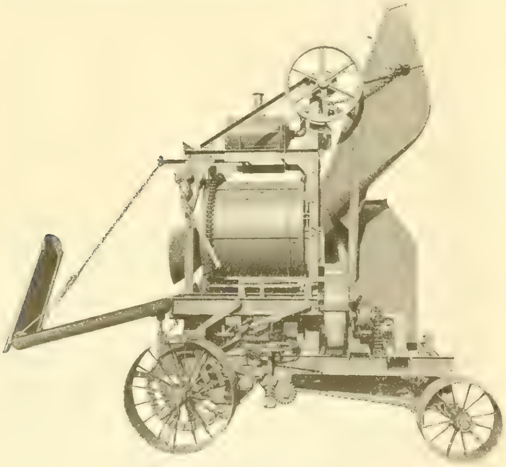
A decided saving in the cost of road construction has been effected by F. A. Albee, contractor, Natalbarry, La., by the use of Duplex 4-wheel drive trucks. Mr. Albee employs his trucks not only for hauling materials but he also uses them in pulling graders. The truck shown in the accompanying illustration is hauling 3½ cu. yd. of gravel and also pulling a grader which is cutting 3 in. into the road on one side and 5 in. on the other.



Duplex Truck Hauling Gravel and Road Grader.

NEW RANSOME BANTAM PAVER.

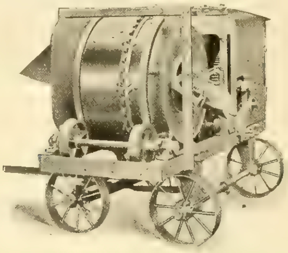
A one-bag batch mixer especially adapted to alley paving, driveway construction and small jobs has been placed in production by the Ransome Concrete Machinery Co., Dunellen, N. J. This new paver is known as the Ransome Bantam. It is equipped with a 4-hp. engine and self-traction and has an open end pivot hopper with a dumping bar for quick charge. The distributing chute is 10 ft. long, swings through a half circle and has an intermediate gate. The machine is provided with an automatic water measuring tank, similar to those on the Standard Ransome mixer.



Ransome One Bag Batch Paver.

NEW END DISCHARGE MIXER.

The Northwestern Steel & Iron Works, Eau Claire, Wis., has recently added to its line two end discharge mixers. These are of 5 and 10 ft. capacity, and, while designed primarily for paving alleys and constructing subways and bridge footings, they are adapted to many other uses, as each will turn practically within its own length. These new mixers are the non-slop "Northwestern," remodeled to give end discharge and easy maneuvering in specially close quarters.



Northwestern Steel & Iron Works' End Discharge Mixer.

MARKERS FOR LINCOLN HIGHWAY.

Enameled markers of the type shown below have been ordered for the Lincoln Highway feeders in and out of Chicago. The markers will be used on the boulevards of the south side and west side parks in Chicago. Beyond the city limits, similar markers will be painted on the telegraph posts by means of stencils.

Markers for Lincoln Highway in and About Chicago.

The design was prepared by Elmer C. Jensen, Chicago, chairman Lincoln Highway Committee of American Institute of Architects.

INDUSTRIAL NOTES.

G. E. Land, recently with the advertising department of the National Tube Co., has been appointed Advertising Manager of the Blaw Steel Construction Co., Pittsburgh, Pa.

M. F. McWilliams of 925 Sheridan Ave., Detroit, Mich., has been appointed District Representative in Detroit for the distribution of the Electromobile Industrial Trucks and Tractors manufactured by Orenstein-Arthur Koppel Co., of Koppel, Pa.

Walter A. Zelnicker Supply Co., St. Louis, Mo., and allied companies have secured the services of Charles H. Trapp, who is to act as confidential secretary to Mr. Zelnicker, the president. Mr. Trapp was formerly associated with James Stewart and Company in St. Louis, Denver and Idaho, and lately with Mr. Terrell Croft, Consulting Electrical Engineer, St. Louis.

The Westinghouse Electric & Mfg. Co. has just announced the granting to its employes another advance in wages, effective May 16, amounting to 10 per cent. This will affect all of the workmen in the shop and practically all of the office force, except a few of the higher salaried employes. This is one more of a number of raises in wages granted to the workmen of the shop, which raises represent a general increase, in a period of two years, of practically 40 per cent.

The H. W. Clark Co., Mattoon, Ill., manufacturers of the Clark Meter Box and waterworks appliances, whose factory was destroyed by a tornado two weeks ago, will be manufacturing again within a few days. In the meanwhile the company is in a position to take care of all orders and to render the usual prompt service. The stock of finished goods was undamaged by the storm. There has been scarcely a lull in the company's business and shipments have been going forward regularly.

The Pittsburgh-Des Moines Steel Co., formerly known as the Des Moines Bridge & Iron Co., with works at Pittsburgh, Pa., and Des Moines, Iowa, has recently established a new plant at Chatham, Ontario. This Canadian branch of the company, known as the Canadian Des Moines Steel Co., Ltd., has purchased the property of the Chatham Bridge Co., Ltd., and has enlarged and completely equipped this plant to handle the manufacture of all standard types of steel structures, including mill buildings, office buildings, fire escapes and bridges. In addition to this they will also make a specialty here as in the states, of the manufacture and erection of elevated steel tanks and other special structures such as standpipes, storage tanks, smoke stacks, barges and coaling stations.

Waterworks and Hydraulic Issue
of

Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

First Wednesday Each Month............Roads and Streets......$1 Yearly
Second Wednesday Each Month, Waterworks and Hydraulics.......$1 Yearly
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Volume XLVII. CHICAGO, ILL., JUNE 13, 1917. Number 24

TO WHAT EXTENT SHOULD WAR ECONOMIZING BE CARRIED?

With considerable unanimity bankers and political economists have been urging the public to curtail expenditures for "luxuries," in order that funds may be available for war. But we have neither seen a definition of the term "luxury" nor an estimate of the extent to which the purchase of "luxuries" should be curtailed.

What is a luxury? Probably there are almost as many conceptions of the meaning of the word as there are people who use it. If a luxury is anything that it not a necessity, what is a necessity? The bare necessities of life are meager enough. A bowl of rice thrice daily, a few yards of cotton goods yearly, and a beggarly hut comprise the sum of a Chinaman's necessities. From this annual pittance to the fifty-fold purchases of the average American workman, you may draw the luxury line wherever you choose.

Since, then, there is no absolute boundary between extravagance and thrift, between luxury and necessity, people should be instructed as to the nature of the economic problem that confronts a nation at war, instead of being exhorted to "economize" blindly. Were everyone to save to the limit, fully half the wage-earners in this country would be without jobs within a few weeks. What, then, is the extent to which economizing should proceed? Plainly the answer is to be found only after determining the ratio of war taxation to the gross annual income of the entire nation.

The gross annual income is approximately fifty billion dollars, and the first Liberty Loan is to be two billion dollars, which is 4 per cent of the annual income. Another two billions will be raised by direct taxes, which is another 4 per cent, making a total of 8 per cent of the gross annual income. Beside this, we are to loan the Allies almost an equal amount, but, since they must pay us interest thereon, we shall increase our annual revenue by exactly as much as we increase our interest expenditures thereon. So we come back to the important fact that if 8 per cent of the gross annual income be set aside annually for war purposes it will suffice for our present war needs.

A still better way of determining the extent to which economizing should be carried consists in estimating the number of American workers who will be diverted from the paths of peace to the paths of war. In round numbers there will be 1,000,000 Americans in arms, which is less than 4 per cent of the male population of 18 to 60 years of age. It has been stated that for every man at the front there must be another engaged in producing ammunition, instruments of war and transportation connected therewith. Hence a total of 8 per cent of our male population of working age (18 to 60) will be diverted from peaceful to warlike occupations. This may be too low an estimate, but an error in it will be more than offset by the speeding up of the working forces. Indeed, if many women enter the industrial ranks we shall witness the anomalous spectacle of an actual increase in the total output of American industries.

View the matter as we may, the outstanding fact is that, if economizing extends much beyond 8 per cent of the average annual income, many people will be thrown out of work. Evidently there will soon be a marked lull in the advice to economize, for it will soon be apparent that this war is going to absorb only a small part of our national energy.

Assuming, then, that about 8 per cent of our gross income must be diverted to war purposes, where should the knife of economy be applied? Should we cease building industrial plants, roads, water works, buildings and other permanent additions to national wealth? Or should we eliminate some of the things that we consume as fast as produced, without adding one iota to our productive capacity? The questions are self-answered.

Paish, the English economist, says that in times of financial stress American food consumption has decreased 20 per cent, indicating a food extravagance and waste sufficient to feed all the Allied armies. Without enumerating the possibilities of economizing in the use of high-priced clothing, useless beverages, etc., it is evident that the entire saving necessary to finance our part of the war can readily be effected without the slightest slackening in the construction of public works or of industrial plants. If, in addition, we speed up our productivity through the greater and more intelligent use of labor-saving equipment, and if we introduce methods of scientific management throughout the country, we shall repeat the industrial history of our Civil War, when agriculture, manufacturing, railway building, etc., experienced a boom that had no previous parallel.

WILL HIGH CONTRACT PRICES LEAD TO DAY LABOR ON PUBLIC WORKS?

The Philadelphia "Bulletin" advises the Pennsylvania Highway Department not to curtail road construction because contract prices are high, but to purchase equipment and build the highways by day labor. The "Bulletin" says:

> Improved highways would prove of importance in the strategy of military operations should war come to these shores. In the period of peace good roads mean decreased expense of transportation, and particularly at the present time, when the rail routes are overburdened and there is an extraordinary return to highway traffic. The improvement of the state highways is long overdue, and the public interest cannot afford a gap of two years in its achievement, or even a longer delay if the war shall continue beyond that period.
>
> The State Highway Department should not be imposed on by the boosted bids of the war contractor group. It should be able to fix a reasonable figure for its work and offer it at that figure, and if bids are not available on that level it ought to be prepared to proceed with improvements on its own account.

We think the "Bulletin" is unjust in its reference to "the booosted bids of the war-contractor group." With equal fairness one might speak of the boosted price that the "Bulletin" charges for its copies, the price having recently risen to 2 ct. from the old 1-ct. level. The fact is that nearly everything is "up," and is likely to remain "up" for years. Moreover, the public works contractor must insure himself, through high prices, against a possible shortage of labor and materials. We think that many contractors have carried this sort of insurance to an extreme, and consequently that public works authorities may be justified in departing radically from the usual procedure of letting contracts to the lowest bidder.

When the element of risk assumes large proportions, engineers have usually regarded some form of "cost plus" contract as preferable to a unit price of a lump sum contract. We are inclined to think that many engineers will see in the present conditions of uncertainty as to prices, deliveries, etc., abundant reason for doing work on a percentage basis or under some form of contract that relieves the contractor of the risk burden.

There will be other engineers who will prefer to buy or rent construction equipment and undertake work on the day labor plan, if contract prices seem to them to be excessively high. Wherever this is done, we urge engineers to keep careful unit costs and to introduce systems of bonus payment. The Los Angeles Aqueduct was built by day labor and was efficiently managed. A large part of the efficiency of the workmen was attributable to the bonus system of payment.

If a "cost plus a percentage" contract is entered into, a bonus system of payment should be used wherever practicable, for otherwise there is not sufficient incentive. Moreover, the bonus should apply in some form to the contractor himself as well as to his workmen.

We suggest the following general form of contract: Let the engineer put his estimated unit prices into the contract, and let each contractor bid a uniform percentage thereon. Then award the contract to the lowest percentage bidder, stipulating that the contractor shall be paid actual cost plus, say, 10 per cent for profit, provided the total cost is less than his bid; all cost in excess of his bid to be deducted from his 10 per cent fee so long as any part of the fee remains; and thereafter the party of the first part to stand the loss.

This contract could be modified in several ways. Thus, a lower percentage for profit could be provided, and a monthly rental paid for each item of equipment furnished by the contractor; the party of the first part having the option of furnishing any part or all of the equipment.

Merely because bids are high should not deter engineers from working out methods of continuing public works. High wages are here to stay, and will not recede after the war. The same holds true of many kinds of materials, particularly those in whose production the labor cost is the predominant part.

FINANCING THE DEVELOPMENT COST OF FARM LAND.

We believe it was Henry C. Carey, the American economist, who held that nearly all land has become an instrument of production as a result of some sort of reclamation, and that land value is due to the labor expended upon it in the past. This last part of Carey's theory of land values is not of much assistance in determining land values. Yet it is evident that no land reclamation is undertaken unless it is estimated that the resulting value will exceed the entire cost of reclamation, inclusive of financing the project.

In estimating the cost of reclaiming land and of selling it, engineers are apt to underestimate, even if they do not entirely overlook, two items: First, the interest and taxes on the investment prior to making the sale. Second, the cost of selling the land.

The cost of selling reclaimed land usually amounts to 25 to 30 per cent of the selling price, and the fixed "carrying charges" prior to the sale may easily exceed 30 per cent. Settlers must be induced to occupy the land. Frequently several successive settlers make partial payments and fail before a settler who is able and competent to stick it out is secured.

The Lewiston-Clarkston Improvement Co., of Southeastern Washington, has found it profitable to lease reclaimed land in small tracts prior to selling it, and to use this method as a means of effecting sales to competent farmers. The tenant pays one-third of his harvested crop as rental to the company. The capital of the tenant is thus left free to improve the land and secure a harvest. The company is enabled to pay a considerable part of the "carrying charges" from the rental, and to eliminate almost entirely the cost of selling the land, for a successful tenant automatically evolves into a purchaser.

If reclaimed land, inclusive of water, has cost $150 an acre; if its harvest is worth $24 an acre, and if one-third of this, or $8, is paid as rental, it is evident that if the annual "carrying charges" are 7 per cent, or $10.50, the rental will pay all but $2.50 of the "carrying charges." Under such conditions, if a company can secure tenants shortly after the land is prepared for occupancy, it is evident that the financing of the "carrying charges" until sales are made need not exceed, say, 10 per cent of the cost of the land. If, then, the cost of securing tenants and making sales is kept within 5 per cent—as it should be under this method—the combined carrying charge and selling cost may be kept down to $15 per cent.

Whether the engineer is himself a land promoter or is "merely the engineer" of a land company, it should be his function to study the development costs, the carrying costs, and the selling costs. The engineer's ultimate aim should be to "do as much with one dollar as any fool may do with two," not only during the construction period but during the subsequent development period.

Engineers have been abundantly damned for underestimates of construction costs. Now that they are gradually wiping out this form of criticism, let them be careful that they do not incur condemnation for underestimating the costs incident to the development period.

OPPORTUNITIES FOR HYDRAULIC ENGINEERING ON OUR FARMS.

There are 14,000,000 acres of land in the northern central states that are unproductive because of excess of water. In some cases the land is a swamp, but in most cases the soil is merely saturated with water. As it stands this vast acreage has only a prospective value. Yet most of it can be drained at a cost far below the thus created value of the land. Capital must be put into this land, but, before capital will come, brains must map the projects and disclose the profits. What sort of brains is more capable of reclaiming this acreage than the brains of engineer promoters? What time more opportune than the immediate future for the promotion of land reclamation?

The editor recently rode through one of the most beautiful residential suburbs of Kansas City, where hundreds of fine homes have been erected during the past few years. He was told the history of this district, and since the tale bears a message to engineers it will be repeated briefly.

A young man, fresh from the State university, without capital, persuasive and ambitious, came to Kansas City. He decided that the town needed more elbow room, and that he was the person to jostle crude nature aside and make the room. So he began by studying the outlying districts, both as to their topography and their availability for home sites. He selected an area owned by several well-to-do farmers, and then undertook to convince them that he was the one man to whom they could most profitably intrust the marketing of their property. Alert, energetic, well spoken, self-confident, he won his first move on the real estate chessboard. Then came move number two. He must be supplied by the owners with capital to grade, pave and otherwise prepare for residence a large section of the land. The California method of laying out handsome city additions was expounded, and the owners were enthused with the prospect. Not a lot was to be sold until many streets and walks were entirely ready. There was to be no half-finished project with a questionable ending offered to the public. The owners assented, and the young man had successfully made move number two. Move number three was the advertising and marketing of the lots; and this was conducted with characteristic novelty and assurance. The public came, saw and purchased, even while the oldest real estate dealers in Kansas City were wagging their heads and predicting a fiasco.

The only feature that mars this true story as a moral for us is the fact that the young man of whom it is told is not an engineer. But if this young man, in spite of a lack of engineering training, was able to convince a group of farmers that he was capable of conducting an enterprise that was 75 per cent engineering, surely an engineer should never hesitate to attempt the promotion of any similar project.

For every farm thus convertible at a profit into city lots, there are hundreds of farms convertible into better farms through drainage and irrigation. Let civil engineers better themselves, as did the young university graduate who put a lot more "can" into Kansas City. Let them cease waiting for others to initiate enterprises. And let none excuse himself for lack of initiative on the score of lack of capital.

WHAT IS THE MATTER WITH WATER WORKS SUPERINTENDENTS?

The sparse attendance of superintendents at the annual convention of the American Water Works Association caused comment, but even more significant was the paucity of papers and discussions by superintendents. More than two-thirds of the papers were written by engineers who are not superintendents, and, of the remaining third, many of the best papers were written by superintendents who are trained engineers.

It is a common excuse that superintendents are "practical men" and not writers, but what kind of a "practical man" is he who has little or nothing to say on the very practical subject of operating and managing a water works plant? We venture the prediction that the type of superintendent who thinks that he demonstrates his practicability by his silence is a type that will soon disappear. Will he give way to the engineer type? Or will the talkative superintendent evolve from the present non-talkative type, in self-protection? Certainly the day of the silent manager of public works is drawing rapidly to a close, for it is already pretty clearly evident that the manager who passes along no knowledge to his fellowmen usually has precious little knowledge to pass along.

ADVANTAGES OF THE COST PLUS A FEE CONTRACT IN WAR TIME.

The announcement that most of the military cantonments are to be built under the cost plus a percentage form of contract should serve to cause engineers to recommend some such contract for other public works in many places.

Press reports state that, in order to expedite the cantonment work, neither lump sum nor unit price bids will be called for.

> This decision has led the advisory committee of the Council of National Defense to counsel the Quartermaster's Department to make contracts on the percentage basis.
>
> In doing this all sorts of precautions and checks have been provided in order that only the ablest and most honest contractors be given contracts. To begin with, a full set of questions have been sent to all the leading contractors of the country.
>
> They are asked to tell of the work they have done in the last three years, its size, etc. They are asked to tell how large a number of men they are prepared to keep in camps. In all a pretty complete history of their operations is required, with references.
>
> In addition to this, confidential questionaires have been sent to leading engineers and architects asking them about each contractor, his integrity, his reputation for finishing work on time and his equipment.
>
> These sets of answers have been put into the hands of one of the best judges of contractors in this country. It has long been his business to judge contractors for great security and guaranty companies. He goes over the questions and then gives the Quartermaster's Department his judgment, whether in his opinion the contractor's offer is so sound that he would be willing to advise a guaranty company to go on his bond.
>
> The contracts are made on a 7 per cent basis to cover overhead costs and contractors' compensation, with an upset limit of $250,000. Before anyone decides this is too much and quotes some contractor who says that he would be glad to do the work without profit, he should look more closely into the case.
>
> On an average it is estimated that all of these contractors have an overhead charge of three and one-half per cent. This means that on a million dollar contract the contractor earns $35,000.

It is stated that the government will buy small tools and will pay rental on all heavy equipment. On jobs of $100,000 or less the contractor's percentage fee will probably be 10 per cent. On jobs of $500,000 or more it will be 7 per cent. For jobs between $100,000 and $500,000 percentages between 7 and 10 per cent will be allowed.

In addition to the time saved through adopting a cost plus a fee contract, there will probably be a saving in cost at this time when a reliable contractor's price is apt to include a pretty high insurance against financial risks.

The chief objection to the cost plus a fee contract is that it does not provide sufficient incentive for a contractor to exert himself to the limit to keep costs down. If, however, the contractor's fee is made dependent on his efficiency as a manager, this objection vanishes. We have suggested elsewhere that it would be feasible to penalize the contractor up to the full extent of his fee for failure to perform the labor within specified unit costs. Also it would be feasible to increase the fee if the labor costs were less than a specified amount per unit of work.

Some form of cost plus a variable fee contract can be contrived for any given class of construction work. Wherever work is being held up because of high contract prices, engineers should address their attention to the "cost plus" form of contract.

PHILADELPHIA AGAIN SLIPS BACKWARD.

The resignation of William H. Connell, chief of the Bureau of Highways of Philadelphia, again illustrates how difficult it is to keep a "reformed city" in the reform ranks. Under Mayor Blankenburg the heads of many of the bureaus were experienced civil engineers of whom Mr. Connell was one. Under Mayor Smith, the present mayor, there has been increasingly evident a determination to replace engineers with politicians.

Street cleaning in Philadelphia is done by contract, and these contractors have long been powerful in political affairs. Mr. Connell had penalized the street cleaning contractors repeatedly for failure to live up to specifications. Recently the city council, with the mayor's approval, created a new department to take charge of street cleaning and garbage removal, and thus "relieved" Mr. Connell of these duties. Then Mr. Connell relieved himself of all remaining duties by resigning as head of the Bureau of Highways, whereupon the mayor and others were "greatly surprised."

We venture to predict that this is only the beginning of surprises for Mayor Smith and his associates, and that the next election will give them a climax surprise from a public that has had its appetite whetted for more engineering management of city bureaus. Indeed, might not political reformers in Philadelphia do well to consider the nomination of William H. Connell for the mayorship?

THE EFFECT OF WAR ON AGRICULTURE AND ITS SIGNIFICANCE TO ENGINEERS.

In 1864, 70,000 reapers and mowers were manufactured in America, or twice as many as in 1862, yet manufacturers were unable to supply the demand. In 1864 agricultural prices were two to threefold what they had been in 1861, before the Civil War started. "This marvelous agricultural prosperity of a nation engaged in one of the world's most formidable wars has no counterpart in modern history," according to Encyclopedia Britannica.

It is apparent that American history is about to repeat itself, and on a larger scale. Great income from crops and greater demand for farm produce than can be supplied, together are leading to an unprecedented use of farm tractors, motor trucks and other machinery.

As a result of the vast development of farming during the Civil War, our railway systems began to expand, and their expansion followed close upon the growth of farming territories. There is strong likelihood that the same thing will occur again during the next few years, provided the rate regulating commissions are liberal in their treatment of the railways.

Profits from farming will have an enormous effect on the development of irrigation throughout the United States. Irrigation is in its infancy, and agriculturists have scarcely begun to appreciate its possibilities. Even hydraulic engineers, unless they have studied irrigation, lack an appreciation of the latent magnitude of the field for irrigation. In common with most men, they hark back to the days when irrigation was applied only in arid areas, and they fail to note its slow but significant spread through the humid districts. Soon there will come a sudden and general awakening to the economic benefits secured through pumping ground waters for crops and orchards. Engineers can and should be foremost in promoting irrigation by pumping.

TWO BILLION FEET OF LUMBER FOR WAR AND WHAT IT MEANS.

Those whom great war totals have hypnotized will enter another trance when they read that 2,000,000,000 ft. B. M. will be required for the purpose of national defense in the next year. This is the estimate of the Lumber Committee of the Advisory Board of the Council of National Defense. It is a huge total, yet it will not exceed 5 per cent of the annual lumber production of this country. Here are some of the items:

	Ft. B. M.
16 cantonments (1,000 buildings)	500,000,000
250 wooden ships	400,000,000
Navy training camps	200,000,000
Aviation training camps	120,000,000
Army wagons	25,000,000
Gun stocks	10,000,000
Miscellaneous	745,000,000
Total	2,000,000,000

The miscellaneous item includes lumber for cooperage, furniture, docks, trench bracing, factories, railroad construction, etc.

Two billion feet for war and about forty billion for other purposes. This is about the average ratio of all our industries.

TWO MILLION BACK YARD GARDENS.

According to the U. S. Agricultural Department, its campaign for a million back yard gardens has been greatly "over subscribed." Reports received by the Department indicate that 2,000,000 town gardens have been planted this year.

Good! Now let waterworks superintendents make good use of this unique situation. Let them teach the public how to use water for irrigation without wastefulness. Let them show that two or more garden crops can be raised this summer, by irrigation. Let them initiate a campaign for a larger water supply wherever the present supply is inadequate. Let them talk water meters and a sliding scale meter rate, so as to encourage the use of water for garden irrigation. In short, let them do the sort of things that managers of every business do in their efforts to make business grow.

EDITORIAL COMMENT.

There are 100,000,000 acres of swamp land in the United States, of which 75 per cent can be reclaimed for agriculture. If reclaimed and planted to corn, our corn crop would be doubled. These 75,000,000 acres would add nearly 20 per cent to our present acreage of cultivated land. Look to land engineering, you engineers who think the profession is overcrowded.

The Denver Union Water Co. is not only giving away water for back-yard gardening, but has employed an agricultural engineer to advise the company's patrons. This is not only practical patriotism but is good business. We predict that what this company is now doing as emergency education will become its permanent practice. Furthermore, the patrons thus educated to use water for irrigation will be glad to pay a reasonable price for the water.

Although 90 per cent of the services in Columbus, O., are metered, 25 per cent of the water pumped does not pass through the meters. The 4 per cent of unmetered services and pipe leakages account for the unregistered 25 per cent. The daily per capita consumption is 87 gal.

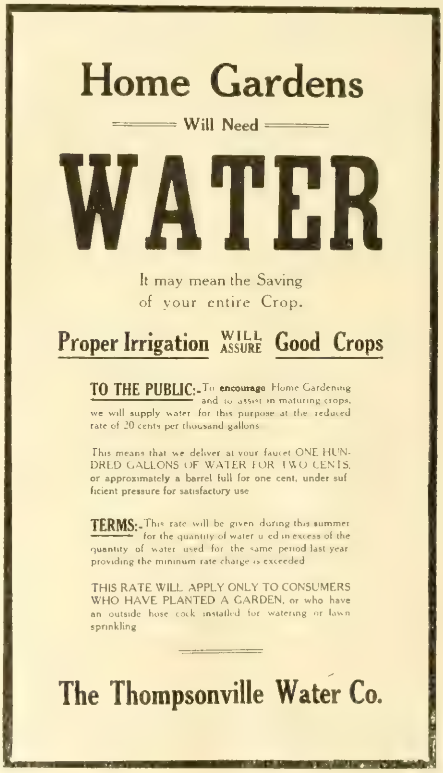
According to Burns & McDonnell, 20,000,000 Americans now have filtered water. This is ten-fold as many as in 1900.

Yarn for cast iron pipe joints is regarded as one of the indispensables, yet war has taught Zurich, Switzerland, that paper can be substituted for hemp. Newspaper is made into cones 6 in. long and ¼ to ½-in. diameter, which are nested and pasted together. The paper is waterproofed with tar oil.

HOME GARDENING PROPAGANDA BY WATER CO.

To the Editor: It may be of interest to your readers to know what results we have obtained in eliminating waste of water by the introduction of meters.

The property was taken over by its present owners about three years ago. At that time there was considerable complaint on account of the inadequacy of pressure, and also a shortage of water. Consumers were forbidden to use hose for sprinkling and the town was obliged to discontinue the sprinkling of streets. The output at the time sometimes ran as high as 1,000,000 gal. a day.



Home Gardens

Will Need

WATER

It may mean the Saving
of your entire Crop.

Proper Irrigation WILL ASSURE **Good Crops**

TO THE PUBLIC:- To encourage Home Gardening and to assist in maturing crops, we will supply water for this purpose at the reduced rate of 20 cents per thousand gallons

This means that we deliver at your faucet ONE HUNDRED GALLONS OF WATER FOR TWO CENTS, or approximately a barrel full for one cent, under sufficient pressure for satisfactory use

TERMS:- This rate will be given during this summer for the quantity of water used in excess of the quantity of water used for the same period last year providing the minimum rate charge is exceeded

THIS RATE WILL APPLY ONLY TO CONSUMERS WHO HAVE PLANTED A GARDEN, or who have an outside hose cock installed for watering or lawn sprinkling

The Thompsonville Water Co.

Advertisement (Reduced One-Half) of Home Gardening Propaganda.

On taking over the property the present owners made improvements; that is, installed a 500,000-gal. elevated tank, raised the pressure over the entire system 30 lb., enlarged the principal mains, and immediately metered the entire system. About 1,800 meters are now in use, and the maximum daily output has been reduced to between 500,000 and 600,000 gal.

We are, therefore, enabled to encourage the use of water, and enclose an advertisement appearing in this connection with the home gardening propaganda.

Walter P. Schwabe,
President and General Manager,
The Thompsonville Water Co.
Thompsonville, Conn.

PREVENTION OF TYPHOID.

To the Editor: I have found much interesting and valuable material in your May 9 Waterworks and Hydraulics number. In your article on the treatment of water with liquid chlorine, on page 426 you ask "Is not such a method of protection infinitely preferable to typhoid vaccination?"

The information in your article is certainly timely and valuable. However, it seems to me that you fail to give recognition to the fact that many cases of typhoid are not contracted from the water supply.

You refer to the large number of cases of typhoid in the army during the Spanish-American war. I had supposed that the typhoid in this case was spread by flies rather than through the water. If this is true, it is a little bit difficult to understand how chlorination of the water supply could have been as valuable a preventive as vaccination.

I am familiar with the two outbreaks of typhoid fever occurring in two widely separated educational institutions within the past five years. There were between 15 and 20 cases, as I remember, at each institution. In one case, the health officers were able to trace the source of infection pretty positively to a carrier working in the kitchen which supplied food to a large proportion of the student body. In the other case the evidence indicated very strongly that one of the dairies supplying milk and butter to the community in which the students resided was responsible for the trouble.

I do not question the value of water sterilization as an aid in preventing disease, but in talking of typhoid prevention, we must not overlook the fact that water is not the only agency through which it is transmitted.

L. E. Conrad,
Professor of Civil Engineering,
Kansas State Agricultural College, Manhattan, Kan.

To the Editor: My attention has been called to your editorial on page 426 of volume 49, No. 19, entitled, "Would you pay two cents a year to insure against typhoid?" I was interested in this editorial, and agree in the main with the argument which you are putting forward. I feel, however, that in the third paragraph you make a statement that is likely to convey a distinctly wrong impression. The implication is clear in this paragraph that the provision of pure water actually insures against typhoid fever, when it is well known that this disease is transmitted in many ways other than through the water supply. Furthermore, it may seem to you hypercritical, but your question, "Isn't such a method of protection infinitely preferable to typhoid vaccination," conveys to my mind a veiled criticism of the typhoid vaccination method. I am sure you did not have this in mind and the context appears to me unhappily placed.

In a word, can you guarantee an individual insurance against typhoid on the basis of two cents a year?

E. J. McCaustland,
Dean, School of Engineering,
University of Missouri, Columbia, Mo.

Open Coagulant Piping at Minneapolis, Minn., Filter Plant.—Open coagulant piping has been installed on the horizontal runs at the filtration plant at Minneapolis. Four-inch cast iron pipe is used. It is readily accessible for cleaning and for painting several times each year with a high grade of graphite or asphalt paint. No leaks have occurred in the pipe during the three years that it has been in service.

SMALL EARTH RESERVOIRS AS AN ADJUNCT TO ELECTRICALLY OPERATED IRRIGATION PUMPING PLANTS.

Earth reservoirs as an adjunct to electrically operated pumping plants are now being used to a considerable extent on small individual irrigation developments in southern California. In the territory served by the Southern Sierras Power Co. some 45 of these storage basins have been constructed within the past two years. The pumping installations in general operate about 700 hours per month and deliver a quantity of water to the storage basins approximately equal to ½ in. of water per acre under cultivation. The reservoir is located upon the highest point of the acreage and the water drawn out through the pipe line as needed.

Three general types of reservoirs have been constructed during the past two years. The least expensive of these is a basin with earthen embankments. This is constructed with a four-horse team and fresno and the bottom is sealed by puddling with clay, adobe or manure. One of these basins, 120x120x5 ft. inside dimensions, clay sealed and holding 450,000 gal., cost $125. Another, 150x150x5 ft., holding 750,000 gal., cost $147. In each of these the embankments were 14 ft. thick at the base and 3½ ft. at the top.

The cement basins commonly have walls 6 in. thick at the base and 4 in. at the top. They are banked around the exterior with earth. One of these basins, 4 ft. high and 75 ft. in diameter, with a capacity of 125,000 gal., was constructed at a cost of $380. This basin holds water for the irrigation of 23 acres of alfalfa and 4 acres of garden truck. The pumping installation consists of a 5-hp. motor and a 2-in. horizontal pump. This outfit delivers water at the rate of 140 gal. per minute. The total expense of irrigation in this case is $250 per year.

The third type of earth reservoir is a basin rendered watertight by spraying the bottom and sides with oil or by applying a coat of cement or lime plaster. This plaster lining is from ½ to 1 in. thick and is applied after the soil has been thoroughly tamped. Two-inch mesh chicken wire is spread over the bottom and sides of the basin prior to the application of the plaster. The plastering costs about 6 ct. per square foot.

In sealing the earth reservoir by spraying with oil the best results have been obtained by using heavy crude oil with not less than 90 per cent asphaltum, heating this from 400 to 450° and pumping it on the ground under pressure in the form of a spray, then following this up with sand, which is spread over the oil. This latter feature is very essential, especially on the banks. Best results are obtained with two coatings of oil, in all about ¾ gal. per square yard. The oil costs from $2 to $3 per barrel put on, depending upon the distance to be hauled. It is delivered to the job in motor truck loads, each of about 25 bbl.

The success of construction work of this kind depends upon the thoroughness with which the work is done. The soil should be worked over very carefully and raked with a fine rake, eliminating any large lumps, etc., that might be either in the bottom or on the banks. A second coat of oil has proven very efficient in making the reservoir tight. It must be borne in mind, however, that the oil used should be asphaltum residue of very heavy specific gravity, about the consistency of heavy coal tar. The sifting of the soil and sand on the hot asphaltum keeps it from running until it has an opportunity to cool and thus gives it a better body to keep it in place.

One of these oil-sealed basins, holding 500,000 gal. of water, was constructed in 1916 at a total cost of $350. The sealing required 75 bbl. of oil and cost $160; construction cost $147, and the gates, inlet and discharge pipes cost $33. This basin is operated in conjunction with a direct connected plant consisting of a 25-hp., 400-volt, 3-phase Westinghouse motor and a special 4-in. Bryon Jackson pump. The basin furnished water for 90 acres of alfalfa and 20 acres of grain.

EXPERIMENTS ON REMOVAL OF IRON FROM WATER SUPPLY OF SPRINGFIELD, ILL.

During the summer of 1916 an experimental plant was operated at Springfield, Ill., for the removal of iron from the city water supply. A description of the plant and the results obtained from its operation were given by Mr. G. C. Habermeyer, engineer of the Illinois State Water Survey, in a paper presented at the first annual convention of the Illinois Public Health and Welfare Association. The following notes are taken from Mr. Habermeyer's paper:

The water for the public supply of the city of Springfield is collected from a bed of sand and gravel about 40 ft. deep overlaid with about 10 ft. of sandy loam. Part of the water is collected in galleries about 20 ft. below the surface of the ground. It flows through these by gravity to a well from which it is pumped to the city. When the ground water is low and when the water consumption is high the galleries furnish only a small portion of the necessary supply, and water is pumped from wells which extend to the bottom of the bed of sand and gravel. For sanitary uses the water is excellent. The following table gives the average iron content of the waters used in the Springfield public supply expressed in parts per million parts of water by weight:

	Gallery Water.	Well No. 1.	Well No. 2.	Well No. 3.	Well No. 4.	Well No. 5.	Well No. 6.
Iron p.p.m.		1.0	1.7	2.6	2.1	3.4	1.2

The removal of iron from waters such as the Springfield public supply involves some process by which oxygen is added to the water or some process by which carbon dioxide is removed from the water. When oxygen is added the object is to oxidize the iron to a form similar to ordinary iron rust. In this form it may be readily removed by filtering through sand. The iron may be in combination with carbon dioxide and when carbon dioxide is present in large quantities it may be necessary to remove it. Oxygen may be added by aeration. Carbon dioxide may be reduced by aeration or by treating the water with a chemical such as lime. It is generally advisable to pass the water through a filter, as the iron in any form settles out slowly if at all.

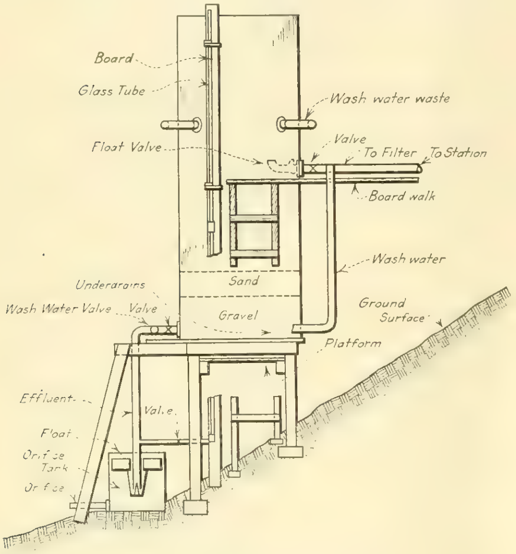


Fig 1—Experimental Filter, Springfield, Ill.

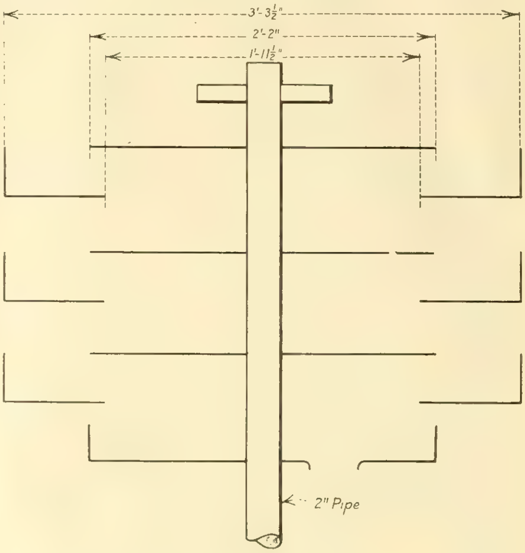
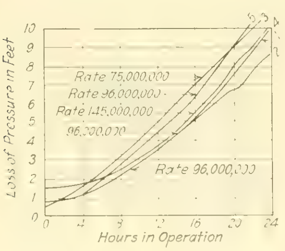


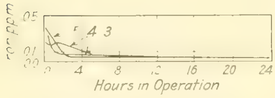
Fig. 2—Section of Aerator.

An experimental plant was built near the pumping station at Springfield to determine:

(1) If the iron could be readily removed by filtration.
(2) The depth of sand to use in filter.
(3) The size of sand to use in filter.



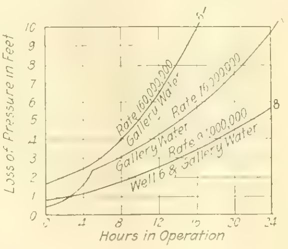
PRESSURE LOST IN FILTER



IRON IN FILTER EFFLUENT

Fig. 3.

Water treated contained about 1.0 part of iron per million. Gallery water tested during night (about 16 hours) contained about 0.8 parts of oxygen per million. Water treated during day from gallery and Well No. 1 contained about 1.8 parts of oxygen per million. Rates given in gallons per acre per day.



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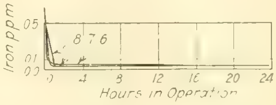
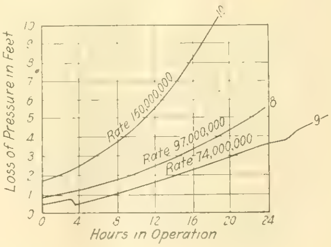


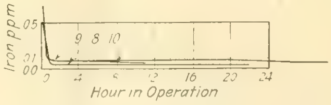
IRON IN FILTER EFFLUENT

Fig 4.

Water treated contained about 1.0 part of iron per million. Water from Well No. 1 and gallery except as noted. Oxygen in water in parts per million: Gallery water, 0.8; Well No. 1 and gallery water, 1.8; Wells No. 1 and No. 6 and gallery water, 3.0. Rates given in gallons per acre per day.



PRESSURE LOST IN FILTER



IRON IN FILTER EFFLUENT

Fig. 5.

Water treated contained about 1.0 part iron per million. Practically all water treated from Well No. 6 and gallery with oxygen content of about 3.0 parts per million. Rates given in gallons per acre per day.

(4) The amount of oxygen necessary in the water
(5) The amount of carbon dioxide allowable in the water.
(6) The amount of agitation of the water desirable.
(7) The best rate of filtration.
(8) The economy of using chemicals for iron removal.
(9) The economy of iron removal and softening.

The experimental plant consisted of an aerator, a filter, a flow-regulating tank and for use when chemicals were added, a few barrels, and a sedimentation tank. Plans of the aerator and filter are shown in Figs. 1 and 2.

The filter and flow-regulating tank were used in all experiments. The filter is a galvanized-iron tank, 40 in. in diameter and 9 ft. high, containing a system of pipes and strainers, a layer of gravel and a layer of sand. When filtering, the water passes into the tank through an opening in the side. The surface of the water is a few inches below the top of the tank, and is held nearly constant by a float valve. The water passes downward through the layer of sand, then through the layer of gravel, then through the strainers into a system of collecting pipes and out of the filter through an opening close to the bottom. Compounds containing iron and certain growths accumulate on and in the sand. As these accumulate the loss of pressure due to friction as the water passes through the filter is increased, and in time it becomes necessary to wash the filter. To wash the filter the flow is reversed, water issuing from the strainers, passing upward through the gravel and sand and out through openings in the side of the tank. The layer of sand is depended upon for iron removal, the deposited iron being somewhat similar to the familiar rust which accumulates on the surface of iron. The gravel and strainers are to carry the clear water into the outlet pipes and to distribute the wash water as uniformly as possible to all parts of the layer of sand. The sand used was ordinary mortar sand from which the coarsest and finest particles had been removed. Of the part used about 90 per cent would pass a screen of 20 meshes to the inch and 10 per cent would pass a screen of 40 meshes to the inch.

The water flows from the filter through a pipe into the regulating tank. This tank has an opening in the side near the bottom and has a float valve attached to the inlet pipe. The float valve holds the water level nearly constant giving a nearly uniform flow through the opening.

In a few experiments the aerator was used. This consisted of plates of galvanized iron so arranged that water dropped from one plate to another.

The results of the experiments are shown in Figs. 3 to 8.

The experiments did not show clearly the effect on loss of pressure in filter due to changes in rate of filtration. Experiments, 17, 18 and 19 (Fig. 8) were made to check up results in this respect. The water treated in these experiments was practically the same as nearly as could be determined. The filter was thoroughly washed before each of these experiments. A very small quantity (2 or 3 lb.) of fine sand was removed from the filter to make it cleaner.

One experiment was run treating the water with lime. The iron content of the water in parts per million parts of water by weight was as follows: City supply 1.4; settled water, 0.5; effluent of filter, 0.05. It is not necessary to add chemicals to remove the iron and only one experiment was run.

Conclusions.

From the results of the experiments the following conclusions may be drawn:

1. The iron content of the water may be reduced to 0.1 part or less per million parts of water by weight by passing the water through a layer of sand.

2. The best size of sand to use was not determined by experiment.

3. With sand of size such as used in the experiments a few inches depth is sufficient.

4. The amount of oxygen in the water necessary to insure removal of the iron need not exceed 0.8 part per million. Increasing the amount of oxygen lengthens the time the filter may be run without washing.

5. The amount of carbon dioxide in the water, in the amounts present, had little or no effect on the amount of iron removed. Removal of carbon dioxide may be a factor in increasing the time the filter may be run without washing.

6. The amount of agitation desirable was not determined by experiments, but the great agitation given by partly closed valves was not thought to be very detrimental.

7. The rate of filtration had little or no effect on the amount of iron removed.

8. The addition of lime has little effect on the amount of iron removed. Its use might cut down the amount of wash water needed to keep the filters clean.

The best size of sand to use depends largely on two factors, loss of pressure in the filters and ease of washing. A coarse sand will give less loss of pressure when filtering, which saves pumping costs. A fine sand can be stirred by water currents with a less velocity than is re-

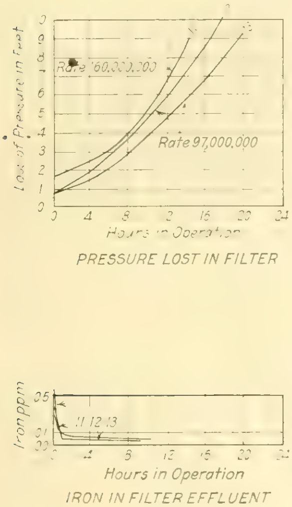


Fig. 6.

Gallery water treated containing about 1.0 part of iron and 0.8 part of oxygen per million. Rates given in gallons per acre per day.

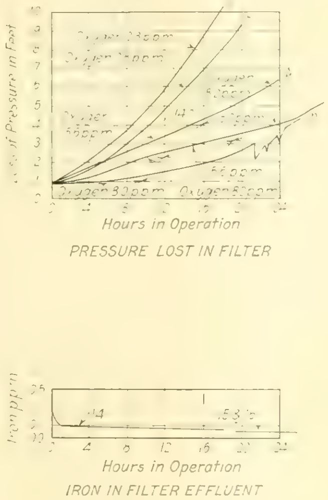


Fig. 7.

Rate of 97,000,000 gal. per acre per day. Gallery water used for experiments 12 and 13 and first 16 hours of Experiment 14. Aerator used in Experiments 14, 15 and 16. Rate of Flow Not Uniform During 16

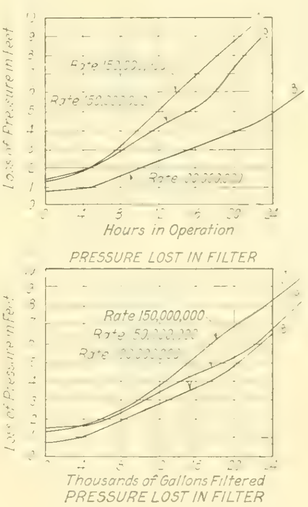


Fig. 8.

Experiments 17, 18 and 19 were made to show effect in loss of pressure in filter due to changes in rate of filtration.

quired to stir coarse sand, and it is necessary to stir the sand in washing, using water, air, or some mechanical appliance. It is believed the ordinary sized filter sand would prove to be the best. At Champaign, Ill.,[*] a coarse sand is used, and it is difficult to keep it clean, though it can not be said that this difficulty is in large part due to the coarseness of the sand.

At Freeport, Ill., lime is added to the water and the sand is kept quite clean without using much wash water. At Champaign the wash water is treated with alum and after settling most of it is pumped back into the supply reservoir and used. Less than 1 per cent of the total supply is lost by washing filters.

PRACTICAL PROBLEMS IN FILTRATION PLANT OPERATION AND THEIR SOLUTION.

In a paper presented May 9 at the Richmond Convention of the American Waterworks Association Mr. Lewis I. Birdsall, Superintendent Water Purification for Minneapolis, Minn., outlines certain practical problems that he has encountered during his experience in the management of mechanical filtration plants, and describes the methods employed for their solution. Extracts from Mr. Birdsall's paper follow:

Chemical Solution Agitators.—The agitating devices for the chemical solution tanks were originally of the two-blade impeller type driven by a 3-in. by 13 ft. hollow vertical shaft direct connected to a 1720 revolution per minute 2 H. P. motor. The high speed of the impellers produced excellent agitation of the solutions, but caused the bending of the drive shafts and armature shafts in the motors. Corrosion of the steel shafting and bronze thrust bearing made much trouble and a high cost of maintenance.

It was decided to reduce the speed of the agitators to approximately 600 revolutions per minute by means of reduction gears, to replace the 6-in. impeller blades with wooden blades 3 ft. long, and to make steady bearings at the center of the vertical drive shafts. These changes eliminated some of the troubles, but there still remained the corrosion of the bronze bearings and the steel shafts. Also the agitators were very noisy, the motors having been set on a steel deck supported by I-beams over the center of the tanks.

The 4-in. hollow steel shafts were replaced with square oak shafts 4 in. by 4 in.; the two blades were made of one piece of oak and having an upward thrust at an angle of forty-five degrees from the horizontal. One horizontal motor of 2 H. P. and 1120 revolutions per minute replaced the three vertical motors, and by means of shafting, clutches and worm drive, the speed of the impellers was reduced to approximately ten revolutions per minute. The blades of the impellers were lengthened so as to reach within 6 in. of the sides of the tanks. The results have been very satisfactory, the noise having been eliminated. One motor does the work of three; there is no more trouble with the shafts or impellers, and the solution is amply agitated.

Portable Valve Opening Motor.—The sluice gates installed in the gate house of the original plant are hand operated, and it requires considerable labor and time to open or close them. When two new coagulation basins were added in 1914 they were equipped with sluice gates, the stands of which were geared so as to be opened or closed in less than five minutes by a portable electric motor furnished by the Roe Stephens Co. from specifications by W. N. Jones.

The outfit consists of a 3 H. P., 660 R. P. M., 440 volt, 3 phase electric motor with control board and extension cable, all mounted on a truck so arranged that the rawhide pinion of the motor can be engaged with the gear of the stand. The truck is fastened to the stand by quick adjusting bolts.

Electric current is obtained from suitable contacts arranged in the wall of the building. The motor is equipped with proper devices to prevent jamming of the gates, and has given entire satisfaction.

Sterilization of Distribution Mains.—Sterilization by means of hypochlorite of lime of all distribution mains larger than 12 in. following their installation and previous to their being placed in service is now practiced in Minneapolis with gratifying results. Experience has shown that flushing a pipe larger than 12 in. does not entirely remove polluting material which has entered the pipe previous to or during the laying of the same. If the pipe is large enough to permit, it is thoroughly brushed out and then, as it is slowly filled, hypochlorite is added at the filling end in amounts large enough to leave a large excess of free chlorine, as shown by tests. Bacteriological analyses are made later to see that the water has been sterilized from one end of the pipe to the other. After allowing the pipe to stand full for several days, the water is completely drained out and the pipe flushed with fresh water if suitable drains are available. Otherwise, the pipe is flushed out through hydrants until tests show the water to be free from the chlorine added.

Automatic Chemical Feed Controllers.—Earl chemical feed controllers were installed as a part of the equipment in the Minneapolis filtration plant, and they have proven to be of the greatest value in operation. Soon after they were put in service trouble developed with the electrical control apparatus. The hydraulic valves on the supply line were controlled by pilot valves, and these, in turn, by electro magnets, through ingeniously arranged contact points on the ends of the balanced arm at the top of each machine. The electro magnets would stick at times unless carefully watched and would cause the hydraulic valves to either close off entirely, thus shutting off the entire supply of chemical solution, or else the valves would open wide and the machines overflow.

One other trouble that developed was the continual chattering of the electrical apparatus, and the constant movement up and down of the hydraulic valves, thus causing a continual fluctuation in the levels of the system. Also it was necessary to keep a small triplex pump running constantly to supply pressure for the hydraulic valves on these machines and a 10-volt, direct-current motor generator machine to supply current.

It occurred to the writer early in 1913 that these difficulties might be eliminated by using balanced float valves and hydraulic control throughout. An experimental controller was made from soil pipe and the plan tried out with success. All of the electrical apparatus was then removed from the master and other controllers, and balanced float valves installed. The master controller was equipped with two ¾-in. balanced float valves, one connected with the water-pressure line, so as to supply water to the right-hand tube of the master controller, and the other to a drain so as to lower the water level in the same tube. The two balanced valves were then connected with a ¼-in. road attached to the balance arm on the master controller in such a manner that as one valve opens the other closes. The relative adjustment of the two valves was secured by turn-buckles and the balanced arm on top of the controller was weighted so as to compensate for the pull exerted on the opposite side of the fulcrum by the two valves.

Each of the three alum and two hypochlorite controllers was equipped with a 2-in. Monel metal balanced float valve, while 3-in. valves with iron body were used on the lime controllers. Each valve was connected directly with the balanced arm on top of the controller by means of ¼-in. rod and turn-buckle as on the master controller. A glass sight tube was placed on each controller and on the master with a graduated scale behind the tube. The result has been even more gratifying than was anticipated, and all troubles have been eliminated. The system automatically regulates itself with changing rates, and aside from a slight adjustment occasionally of the turn-buckles or cleaning of the valves no attention is required. Two triplex pumps, two motor generator sets and complicated electrical apparatus have been eliminated, and there is no more fluctuation of levels in the system.

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[*] Champaign, Ill., and Freeport, Ill., have iron removal plants.

CHLORINE CELL INSTALLATION OF MONTREAL WATER & POWER CO.

The sterilization of public water supplies with chlorine or chlorine compounds, either as an adjunct of filtration or as a sole method of purification, is now standard practice, but the production of electrolytic chlorine and the application of the gas, so produced, to the water to be purified is a development of rather recent date. Since the first of the year the Montreal Water & Power Co., Montreal, Que., has had an electrolytic cell installation in service. Data on the operation of this installation were given by F. H. Pitcher and James O. Meadows, in a paper presented at the Richmond Convention of the American Waterworks Association, from which the following notes are taken:

The chlorine cell installation consists of the following main parts: A salt storage bin having a capacity of 40 tons of salt, the brine saturating and purifying equipment, two 15 H. P. motor generator sets, four chlorine cells, and the silver ejectors and distributing lines for applying the chlorine water to the water to be treated.

The brine saturating and purifying equipment consists of the following parts: Three vertical galvanized iron saturators, 27 in. in diameter by 6½ ft. in height, provided with a spray system at the bottom and an outlet 6 in. from the top; two concrete reaction tanks having a capacity of 82 cu. ft. each. These tanks are built with sloping bottoms, and are provided with a pipe grid for air agitation. Two sand filters are provided for filtering the purified brine, which passes from the filters to the two concrete storage tanks having a capacity of 276 cu. ft. each.

The distributing lines for applying the chlorine water to the water to be treated are 1 in. chemical hose lines, and the chlorine gas is ejected into the water by means of a silver ejector, which maintains a 4-in. vacuum on the chlorine cells and takes the gas from the chlorine main through the ejector to the distributing lines.

The four electrolytic cells are of the Allen-Moore type. Each cell is a standard 600-ampere unit and is 7 ft. long by 20⅜ in. wide. Each cell is provided with Acheson Graphite anode plates, and pure wrought iron perforated cathode plates. The Allen-Moore cell is of the unsubmerged diaphram type and uses asbestos paper for the diaphram material. Unlike several other types of electrolytic chlorine cells, the cell box of the Allen-Moore cell is made of concrete, properly protected at the surface to withstand the action of the chemicals.

The cells are connected in series and are provided with short circuit switches or cut-outs. The voltage carried on each cell is approximately 3.3 volts, and each cell is capable of producing 32 lb. of chlorine per 24 hours.

A small quantity of water under pressure is allowed to flow in the bottom of the saturators, the saturators being charged with salt. A saturated solution of salt is delivered to the two concrete reaction tanks. A sufficient quantity of soda ash is added to the brine in the reaction tanks to combine with the calcium and magnesium salts present in the brine, and the contents of the tanks are agitated for ½ hour to insure complete mixing of the soda ash solution with the brine, and also to hasten the reaction. The solution is then allowed to remain in a quiescent state for one hour to allow the precipitate formed to settle, when the solution is filtered through the sand filters into the purified brine storage tanks. A sample of the purified brine is taken and titrated for residual alkalinity, which determines the amount of hydrochloric acid necessary to add to neutralize the alkalinity and leave a residual acidity of about 0.01 per cent. It is necessary to have the electrolyte slightly acid to prevent the formation of hypochlorites within the cell, and the subsequent loss of cell efficiency.

The cell or current efficiency is computed from the cell flow of caustic liquor, the amount of caustic produced, and the current used to effect the dissociation. The flow of caustic liquor is measured for a certain period and computed as liters flow per hour, and at the same time a portion of the caustic liquor is titrated with normal acid to determine its strength. Knowing the flow per hour and the amount of caustic per liter, the number of grams of NAOH produced per hour can be easily determined, which figure is known as the actual caustic production.

The number of amperes passing through the cell multiplied by 1.49 grams (theoretical NAOH production per hour per ampere) will give the theoretical caustic production, and this result when used as the divisor, and the actual caustic production as the numerator will give a product which when multiplied by 100 will be the percentage current efficiency of the cell. Also as the amount of caustic produced is to the amount of chlorine produced as the atomic weight of NAOH is to the atomic weight of chlorine, the amount of chlorine produced can easily be determined. The amount of chlorine produced can also be determined by direct titration, and this chlorine assay will act as a check on the first determination.

The annual cost of production is arrived at as follows:

Salt at $8.00 per ton	$ 500.00
Power at $30.00 per H. P.	450.00
Interest at 6 per cent on $5,000	300.00
Depreciation at 15 per cent	750.00
Labor and superintendence	500.00
	$2,500.00

Three out of the four chlorine cells furnish the requisite amount of chlorine for sterilization, yielding 90 lb. of chlorine gas per 24 hours or 32,850 lb. per year, making the cost of chlorine produced 7.6 ct. per pound.

The annual cost of sterilization previous to the installation of the chlorine cells was as follows:

Chloride of lime at 3.75 ct. per lb.	$4,105.00
Interest at 6 per cent	150.00
Depreciation at 5 per cent	125.00
Labor and superintendence	500.00
Total	$4,880.00

As the amount of chloride of lime required was 300 lb. per day or 100 lb. of available chlorine, the cost per pound was 13.4 ct. or 5.8 ct. per pound more than chlorine produced by the electrolytic cells.

With normal market conditions the annual cost of the two forms of treatment would be approximately the same, if one did not consider the general depreciation that chloride of lime causes about a water purification plant.

An electrolytic chlorine cell functions at its best when under a constant current load, and for this reason it is good practice not to vary the load, or if varied to bring about the change gradually. Variations in load cause a considerable deterioration of the diaphrams, with a consequent loss in cell efficiency. For this reason automatic control of the chlorine production from an electrolytic cell is not practical, and for the treatment of a large volume of water, without appreciable variations in volume, automatic control is not required, for the dosage can be regulated for the maximum requirements without causing tastes or odors during the minimum consumption periods. The three cells required to supply the chlorine consumed for sterilization are operated with a current load of 500 amperes and 13 volts. The electrolytic cells require very little attention, and up to date have given excellent satisfaction.

The caustic liquor from the cells contains about 12 per cent of sodium chloride and about 10 per cent of NAOH. No recovery of the salt and caustic is attempted, because the amounts of these two chemicals produced is so relatively small that their recovery would not be economical. For large installations the recovery of the salt and caustic is a regular feature of the process, the salt recovered being used over again, and the caustic is concentrated and sold as liquid caustic.

The chlorine cell installation was adopted because of the saving effected over the present high price of chloride of lime, and inability to secure this chemical with any degree of certainty, and also because common salt is very much easier to handle around a water purification plant, and its use in the chlorine cells does not cause the general deterioration about the works that the use of chloride or lime does. Over dosage with chlorine does not cause the trouble that chloride of lime over dosage does, because odors and tastes are not present to the same degree.

DETERMINING DAILY DISCHARGE OF IRRIGATION CANALS AFFECTED BY CHECK CONTROL.

An investigation of the adaptability of the Hall slope method for determining daily discharges of canals affected by variable slopes due to check control was conducted last year by Mr. H. W. Humphrey, junior engineer of the Klamath Project of the U. S. Reclamation Service. A brief synopsis of his report is contained in the June Reclamation Record, from which the following notes are taken.

The Hall slope method, as published in Water Supply Paper 345 of the U. S. Geological Survey, deals with the method of procuring daily stream flow records on rivers whose flow is by some cause retarded so that a variable slope results. In the Hall slope method "it is proposed to base the estimate of daily discharge on both the gage height and the slope—the slope or relative difference in elevations of water surface to be determined by gage height records obtained at two stations the proper distance apart on the stream with gages set to the same datum—and then the slope for each day and at the time of each discharge measurement having been determined to adjust the discharge values on the assumption that for the same gage height and conditions of channel, the velocity will vary with the square root of the slope." In the equations $V = C\sqrt{RS}$ and $Q = AV$, if the gage height and conditions are constant A, R, and C all remain constant, and it follows that V and Q must vary as $\sqrt{S}$.

If we let Q_n be the normal discharge corresponding to H_n, the normal or average difference of elevation of water surface between the two gages, then $\frac{Q_1}{Q_n} = \sqrt{\frac{H_1}{H_n}}$. In this equation Q_1 represents the actual discharge of the stream as determined by the current meter, and H_1 the corresponding difference in elevation of water surface between the two gages. The value of H_n may be arbitrarily assumed, but to make the ratio $\frac{H_1}{H_n}$ as near unity as possible H_n is taken as the average difference in elevation of water surface between the points.

By means of discharge measurements the values of Q_1 may be determined for different gage heights. $\frac{H_1}{H_n}$ will vary with the different measurements and will be greater or less than unity according as the slope of the stream at the time of the measurement is greater or less than the average slope. The values of Q_n as determined from the expression

$$Q_n = \frac{Q_1}{\sqrt{\frac{H_1}{H_n}}}$$

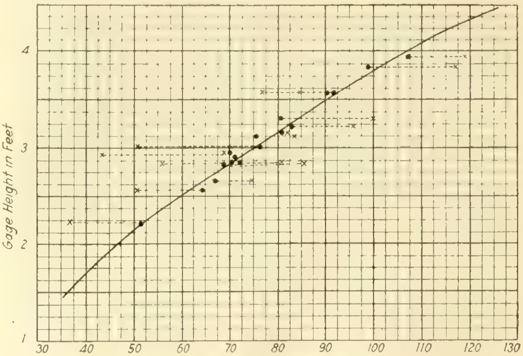
will, however, give a well-defined curve when plotted in the same way as the ordinary discharge rating curve (see diagram), and the "normal" discharge curve having been determined, a "normal" rating table is prepared from it in the ordinary way.

To find the actual discharge of the stream at any stage and for any slope, the "normal" discharge is taken from the "normal" rating table and multiplied by the proper value of $\sqrt{\frac{H_1}{H_n}}$. For simplicity of notation the letter Z is used as representing the value of $\frac{H_1}{H_n}$.

It is evident that the distance between the two gages has no bearing on the results other than that they should be so located as to readily show any change in slope. It must not show any breaks in the profile of the canal surface or any diversions of such size as to influence its hydraulic properties; that is, the hydraulic radius must remain the same throughout the distance.

The "G" canal of the Klamath project, on which this method was tried, diverts from Lost River at the Lost River diversion dam near Olene, Ore. The canal is built to a slope of .0001 and in order to make adjacent deliveries it is necessary to control the water surface by means of a wooden flashboard check located at station 112, or a little more than 2 miles below the intake. It is evident that a change in the flashboards at the check will affect the flow conditions at the intake. A plotting of the current-meter measurements, as indicated on the accompanying diagram, shows a wide variation, and daily discharge deduced from such a record in the ordinary manner is of questionable accuracy.

Gage No. 1 is located about 200 ft. below the intake structure. It is an enameled gage graduated to hundredths and installed with it is an 8-day automatic stage recorder. Gage No. 2, similarly equipped, is located at the check, 11,000 ft. downstream. The difference in elevation for each measurement and also each day is taken from the gage readings and gage graphs of these two stations. During the season 17 current-meter measurements were made and a normal discharge rating curve was developed. The normal fall between the two gages was determined by the summation of the average daily differences for the entire season. This was found to be 0.96 ft. and to simplify the computations a normal slope of 1 ft. was taken and used throughout. In the development of the normal rating curve the normal discharges were plotted, using as ordinates the gage readings at the intake, as shown in the diagram. The curve as shown was drawn giving extra weight to a part of the measurements; yet the difference between the plus and minus plotting is negligible. A table was then made from the curve. To compute the actual discharge the normal discharge is taken from the rating curve, using the reading at gage No. 1 and then multiplied by the square root of Z for the recorded difference in gage readings. For application of this method in the field it is advisable to make up a table of the factors Z and $\sqrt{Z}$ for each hundredth of a foot of gage height.



x Discharge as actually determined with current meter. • Discharge reduced to normal slope

Diagram Showing Normal Rating Curve and Discharge.

In the computations the results were carried to even second-feet as the working conditions do not justify a finer study. Some trouble was experienced with the automatic stage recorders and errors due to frequent turning in or out of water as well as frequent changes in the check. For a more accurate and detailed study, it would have been necessary to have stage recorders of greater range; but a study of these plottings reveals that none show an error of 5 per cent, which taking into account the above-stated conditions shows beyond any reasonable doubt that this method when properly applied will give accurate results and furnish a simple method for the measurement of water in canals affected by change of slope due to check control.

The following recommendations are offered to those who try this method of measurement:

1. Gages should be set to the same datum and installed with automatic stage recorders registering to the nearest hundredth of a foot.

2. Current-meter measurements should be made only when the slope has become stable, as measurements made while a change in slope is in progress will give variable results.

3. The second gage should be located at such a point that the changes in the check will give practically the same hydraulic radius at the second gage as at the first. A gage located at the check, as in the above study, gives too great a change in hydraulic radius during the extreme sudden changes in check control. If the slope will permit, the second gage should be placed about halfway between gage No. 1 and the check.

4. Changes in the check control should be reduced to a working minimum. Changes should be recorded as to time and amount of change at both intake and check.

After a station has been established and a normal rating curve determined, the operation and maintenance expense of the station is greatly reduced, as only a limited number of current-meter measurements are necessary. It is also possible to compute the actual flow at any time by reading the two gages and applying the normal rating curve and correcting for true discharge. Without this method, it would be necessary to make a current-meter measurement or else a deduction that would be subject to great inaccuracy.

The following excerpt from the table of daily discharges of "G" canal, showing the discharges for the first 10 days in July and August, indicates the variable character of the flow in this canal due to the check control and the usefulness of this method in its operation:

Date. 1916.	Gage 1.	Gage 2.	Difference or fall.	$\sqrt{Z}$.	Normal discharge, Q_n.	True discharge, $Q_n \sqrt{Z}$.
July 1	3.90	3.18	0.72	0.848	104.0	88
2	4.00	3.36	.64	.800	108.0	86
3	3.83	3.30	.53	.728	101.0	74
4	3.32	2.89	.43	.656	84.6	55
5	2.96	2.76	.20	.447	73.8	33
6	2.70	2.50	.20	.447	66.0	30
7	2.52	2.31	.21	.458	60.6	28
8	2.52	1.82	.70	.837	60.6	51
9	2.50	1.82	.68	.825	60.0	50
10	2.48	1.82	.66	.812	59.4	48
Aug. 1	3.53	2.74	.79	.889	90.9	81
2	3.65	2.83	.82	.905	94.5	85
3	3.80	2.76	1.04	1.020	100.0	102
4	3.80	2.78	1.02	1.010	100.0	101
5	4.03	2.76	1.27	1.127	109.0	123
6	3.95	2.72	1.23	1.110	106.0	118
7	3.98	2.64	1.34	1.153	107.0	124
8	3.75	2.42	1.33	1.153	98.0	113
9	3.61	2.28	1.33	1.153	93.3	168
10	3.63	2.31	1.32	1.148	93.9	103

It is planned to continue this study during 1917 by moving gage No. 2 about 1,200 ft. up the canal and installing more reliable stage recorders in conjunction with hook gages, thus reducing all possible errors to a minimum.

Detailed Investigation of Surface Waters of Kansas.—The Kansas Water Commission has arranged co-operation with the United States Geological Survey for a detailed investigation of the surface waters of Kansas. In carrying out this work the Survey established on June 1 a district office at Room 25, Federal Bldg., Topeka, Kans., under the direction of Roger C. Rice, District Engineer. The Kansas Water Commission comprises the following named Commissioners: Arthur Capper, Governor of Kansas, ex-officio chairman; T. J. Strickler of Topeka, Chief Engineer of the Public Utilities Commission, secretary; H. A. Rice, professor of civil engineering, Kansas State University, Lawrence; and H. B. Walker, Drainage Engineer, Kansas State Agricultural College, Manhattan, who is engineer for the Commission. It is planned to establish stream gaging stations on the more important streams and tributaries of the State. These records will be of especial value in assisting with the solution of the serious flood problems of eastern Kansas. One of the first gaging stations to be installed will be on the Kansas River at Topeka.

OPERATING RESULTS OF PLANT FOR REMOVAL OF IRON AND MANGANESE FROM GROUND WATERS AT LOWELL, MASS.

A plant for the removal of iron and manganese from the well water supply of Lowell, Mass., was completed in the fall of 1915. The plant has a gross capacity of 10,000,000 gal. daily. It comprises six coke prefilters 10 ft. deep and 0.15 acre in total area, two settling tanks of a total capacity of 500,000 gal., providing approximately one hour sedimentation, six sand filters with a total area of one acre, and a filtered water reservoir of 1,000,000 gal. capacity. The plant was designed by Mr. Frank A. Barbour, consulting engineer, Boston, Mass. The following information on its operation is taken from a paper presented by Mr. Barbour at the Richmond convention of the American Water Works Association:

Water was first applied to the prefilters in October, 1915, but it was not until July, 1916, that the sand filters were placed in regular service—this because of the time required to ripen the prefilters, the desire to avoid starting the sand filters in winter without more knowledge of what surface cleaning would involve, and finally because of the delay caused by the necessary repairs to the underdrain system.

The following table shows monthly averages of analyses of the ground water as drawn from the wells during the year 1916:

Month.	Dissolved Oxygen. Per Cent of Saturation.	Parts per Million: Carbonic Acid.	Iron.	Manganese.
January	11.6	22.8	1.64	2.53
February	11.4	21.8	2.20	2.44
March	11.2	22.0	2.34	2.56
April	12.8	22.0	1.64	2.45
May	15.6	21.4	2.28	1.94
June	14.9	20.8	2.35	1.73
July	14.2	20.8	1.92	1.59
August	15.0	21.3	2.28	1.69
September	16.0	21.4	2.43	1.89
October	15.8	21.1	2.51	1.89
November	15.3	21.0	2.28	2.05
December	16.7	20.2	2.09	2.09
Average	14.0	21.4	2.16	2.07

The free ammonia in the well water has averaged for the year .33 p. p. m., the albuminoid ammonia .057 p. p. m. and the total hardness 25 p. p. m.

The prefilters have been operated at an average rate of approximately 50,000,000 gal. per acre daily. The carbonic acid and dissolved oxygen in the water, as applied to the prefilters after aeration, have averaged 14.0 p. p. m. and 52.9 per cent of saturation, respectively. The prefilters have been backflooded to an elevation 1 to 2 ft. below the surface of the coke, and the carbonic acid and dissolved oxygen in the effluent have averaged 13.3 parts per million and 54.5 per cent of saturation.

Tables I and II show the work done by the prefilters and settling basins in the removal of iron and manganese during the year 1916:

TABLE I.—MONTHLY AVERAGES OF IRON IN PREFILTER EFFLUENT AND SETTLING BASIN EFFLUENT.

Date.	Iron p.p.m.: Prefilter. Effluent	Iron p.p.m.: Settling Basin Effluent	Iron—Per Cent Removed: By Prefilters	Iron—Per Cent Removed: By Prefilters and Settling Basins
January	0.95	0.89	42.0	45.8
February	0.95	0.84	56.8	61.8
March	0.95	0.75	59.4	68.0
April	0.79	0.58	51.7	64.6
May	0.90	0.57	60.6	75.0
June	1.06	0.58	54.8	75.3
July	0.89	0.76	53.7	60.4
August	1.14	0.84	50.0	63.2
September	1.29	0.98	48.2	60.6
October	1.34	1.00	51.4	60.2
November	1.16	0.88	49.1	61.4
December	1.05	0.80	49.8	58.8
Average	1.01	0.79	52.0	63.4

TABLE II.—MONTHLY AVERAGES OF MANGANESE IN PREFILTER EFFLUENT AND SETTLING BASIN EFFLUENT.

Date	Manganese p.p.m.: Prefilter. Effluent	Manganese p.p.m.: Settling Basin Effluent	Manganese—Per Cent Removed: By Prefilters	Manganese—Per Cent Removed: By Prefilters and Settling Basins
January	1.93	1.84	23.7	26.9
February	1.78	1.70	27.1	30.3
March	1.70	1.63	33.6	36.8
April	1.61	1.57	33.1	35.9
May	1.23	1.15	36.6	40.8
June	1.05	1.00	39.3	42.2
July	0.93	0.82	41.5	48.1
August	0.97	0.88	42.6	[illegible]
September	0.96	0.92	19.2	[illegible]
October	1.11	1.08	29.7	42.9
November	1.05	0.95	[illegible]	[illegible]
December	1.08	0.90	18.3	41.1
Average	1.29	1.21	37.8	41.6

The removal of 52.0 per cent of the iron and 37.8 per cent of the manganese, or the interception of about 100 lb. of metal daily by the prefilters, makes the unloading of the resulting mass of hydrate an important factor in the control of the plant. This is accomplished by filling the prefilter tank to within 1 ft. of the top of the wall and then opening the gate in drain to river. The 4 ft. of water over the coke under average conditions disappears in four minutes, or falls 10 in. per minute—providing a velocity through the voids in the coke sufficient to remove all but a fairly constant percentage of the metallic deposit. On the average the prefilters have been flushed once a week during the past year, and the wash water has equaled 0.80 per cent of the quantity filtered. In addition to the weekly flushing, the upper 8 to 12 in. of the coke has been loosened by forks at intervals of about one month to prevent matting—and experience to date indicates that by this weekly flushing and occasional loosening of the surface layer the deposit of metallic hydrates in the coke can be controlled and a uniform condition maintained.

The settling basins were cleaned once during 1916, a deposit of about 1 in. of gelatinous iron and manganese precipitate being flushed into the sewer. From Tables I and II it will be seen that the settling basins removed only 11 and 4 per cent, respectively, of the iron and manganese in the raw water. The provision of one or more contact baffles of coarse gravel in each of these basins to assist coagulation and intercept some of the metallic hydrate which now reaches the sand filters has been suggested.

The sand filters have been in continuous service since July, 1916, and have operated at rates varying from 6,000,000 to 7,000,000 gal. per acre daily, depending on the water used by the city. During the year a small experimental sand filter, receiving effluent from prefilter No. 3, has been run with equally good results at a rate of 10,000,000 gal. per acre daily, and there is no doubt that, when the demand makes necessary, a rate of 10 m. g. d. per acre or higher can be maintained in the sand filters.

The following table shows monthly averages of iron and manganese in the sand filter effluent from August, 1916, to February, 1917, inclusive:

	—Parts per Million—	
	Iron.	Manganese.
1916—		
August	.30	.11
September	.31	.01
October	.29	.02
November	.26	.00
December	.24	.02
1917		
January	.25	.05
February	.23	.03
Average	.27	.03

During the seven months to March 1, in which the sand filters have been in regular operation, the iron in the raw water has been reduced from 2.12 p. p. m. to .27 p. p. m. and the manganese from 2.14 p. p. m. to .03 p. p. m. The water as it leaves the plant is clear and colorless, and experiments indicate that no subsequent precipitate of the residual metallic contents occurs in the water—either cold or hot.

The sand filters, thus far, have been raked when the loss of head, due to the accumulation of surface deposits, reaches 5 ft., or two-thirds of the maximum possible loss of head. The yield between rakings has ranged from 100,000,000 gal. per acre to 50,000,000 gal. per acre—growing less with each raking, and finally necessitating scraping and removal of the surface slime. To March 1 the filters had been scraped twice—about 1 in. of sand being removed each time. The yields between scrapings were 467,000,000 and 412,000,000 gal. per acre, the decreased yield of the second run being due to compacting of the sand by inexperienced workmen rather than of general significance.

The cost of raking has averaged $0.20 per 1,000,000 gal. filtered. of scraping and removing the dirty sand $0.50 per 1,000,000 gal. filtered, or a total of $0.70 per 1,000,000 gal. filtered. No sand has as yet been washed or replaced. These costs are unnecessarily high, due to the inexperience of the workmen and to the fact that adequate pressure for the operation of the ejector is not yet available.

OPERATING RESULTS OF IMHOFF TANK SEWAGE DISPOSAL WORKS OF FITCHBURG, MASS.

The sewage disposal works of the city of Fitchburg, Mass., one of the largest plants in this country using the Imhoff tank system, have now been in operation for over two years. The results attained in this time have been highly satisfactory, and indicate the sufficiency of the works for present requirements and probably for a number of years to come. The following information on the operation of the plant for the 52 weeks beginning Dec. 3, 1915, and ending Nov. 30, 1916, is taken from the report of F. W. Jones, supervising chemist to David A. Hartwell, Superintendent of Sewers:

Grit Chambers—The grit chamber on Water St. has been in operation a total of 274 days. Its use was discontinued from Jan. 31 until April 22 while the alterations were being made, and for a total of 8 days additional for cleaning. It was cleaned three times; in February, before the alterations, when 53.2 cu. yd. were removed, and twice after the alterations, in May, and in the latter part of July, with removals of 45 and 47.9 cu. yd., respectively.

A change in the internal structure makes the work of cleaning much easier, and the material removed is less objectionable to sight and smell. This change consists in dividing the settling chamber lengthwise, so there are now two compartments instead of one. This was done by laying a 12-in. brick wall and placing necessary gates so that either compartment could be cleaned while the sewage was flowing through the other.

The average cost per cubic yard for cleaning the sump and carting the contents 1½ miles to a dump on the disposal area has been $1.90, of which 73 ct. is for hauling and the remainder for handling.

The screen at the Summer St. grit chamber is raked twice each week. The small amount of screenings was removed occasionally to a nearby ash heap and buried. The deposit in the sumps, containing considerable offensive organic matter, has been cleaned out three times, with an average removal of 1.9 cu. yd., which was wheeled to the dump and covered with ashes.

Siphon Chamber—The vertical bar screen, clear space 1⅝ in., in the siphon chamber has been in continuous use. The amount of screenings varied from 0.5 to 1.0 cu. ft. per 1,000,000 gal. of sewage screened; 0.7 to 0.8 cu. ft. is a fair average under normal conditions. Once each week the accumulated material, amounting to a total of 722 cu. ft. for the year, was removed and buried near by, thus preventing any nuisance.

Imhoff Tanks—All the Imhoff tanks have been in operation continuously since Dec. 17, except for short periods when one or more tanks were closed, or when the whole plant was shut down. From Dec. 3 to Dec. 17 two tanks only were in use.

The operation has been interrupted only during periods of continued high flow due to thaws and heavy rains. After the flow reaches a rate of 9,000,000 to 10,000,000 gal., and there seems no probability of immediate decrease, the blow-off in the siphon at the river crossing is opened and the diluted sewage turned into the river. Frequently, however, when the flow rises suddenly, as during thunder showers and midday thaws, the plant is kept running throughout the high rate.

The working of the tanks as a whole has been very satisfactory. No foaming occurred and the scum, which varied in depth from practically nothing in some sections to 3½ ft. in others, was inoffensive. The scum is thicker in the chimneys than in the side vents and thicker in the end chimneys than in the middle ones. It is allowed to remain undisturbed, except to poke holes occasionally that the gas may have free outlet.

During June, owing to continued wet weather and the fact that three of the tanks were full of sludge, due to admission of sludge from the secondary tanks, the efficiency of sedimentation was greatly reduced and the surface of the tanks became unsightly with sludgy froth. The average removal of settleable solids during this month as measured by readings of the daily composites in the conical glasses was only 80 per cent, while for the other months it averaged 97.5 per cent. As soon as the sludge was withdrawn from the full tanks the froth disappeared and the tanks produced the usual good results.

The amount of total suspended matter removed monthly by the tanks varied from 43 per cent in June to 78 per cent in July, an average of 70 per cent. This amounted to a total of 580.5 tons of dry solids. In addition to this, 74.3 tons of dry solids were added from the secondary tanks.

The flow was reversed five times, and measurements made from time to time show that after the hopper bottoms are filled the depth of sludge in each tank is uniform.

On July 17 a green growth covered the surface of tank No. 1, and appeared in lesser quantity on the other tanks. Chloride of lime was sprinkled over the surface, and the next morning the growth had disappeared.

After the raising of the weir level in the dosing tanks to the Imhoff tank level considerable clogging was caused in the nozzles by the increased quantity of floating matter in the sewage which overflowed the scum boards and stop planks during high flow; accordingly the stop planks and screens were raised 3 and 2½ in., respectively, and the scum boards were widened 6½ in. top and bottom. This has prevented further overflows and greatly reduced the nozzle trouble.

The slots are poked almost daily to prevent floating patches of sludge and the surface is skimmed when necessary, so that the tanks usually present a well-kept appearance.

TABLE I -OPERATION DATA OF SEWAGE DISPOSAL WORKS, FITCHBURG, MASS.

Date, 1915-1916.	Average air temperature, degrees F.		Imhoff tanks						Sprinkling filter			
	Max	Min.	Screenings, cu. ft.	Days in operation.	Total gallons treated.	Average gallons treated per 24 hours	Per cent suspended solids removed.	Per cent settleable solids removed.	Days in operation.	Total gallons filtered.	Average gallons filtered per 24 hours.	Nozzles cleaned.
Dec. 3, 1915—Dec. 30, 1915..	34.8	22.5	36	27.12	64,395,000	2,374,450	64.80	96.0	27.08	64,145,000	2,368,720	833
Dec. 31, 1915—Jan. 27, 1916..	36.1	21.0	37	27.32	81,315,000	2,976,390	70.44	98.4	27.32	81,315,000	2,976,390	2,062
Jan. 28, 1916—Feb. 24, 1916..	32.1	15.0	50	28.00	66,660,000	2,380,710	72.01	99.0	28.00	66,660,000	2,380,710	1,034
Feb. 25, 1916—Mar. 30, 1916..	37.1	19.8	98	29.30	103,390,000	3,528,670	64.82	97.5	28.70	97,500,000	3,397,210	1,139
Mar. 31, 1916—April 27, 1916..	54.0	36.5	79	22.51	105,570,000	4,689,910	63.00	98.4	15.86	70,695,000	4,457,440	529
April 28, 1916—June 1, 1916..	69.1	46.7	89	32.70	123,210,000	3,768,840	55.63	94.8	31.90	117,980,000	3,698,430	772
June 2, 1916—June 29, 1916..	72.5	52.6	59	23.80	99,070,000	4,162,600	43.39	79.8	23.60	97,635,000	4,137,080	2,167
June 30, 1916—July 27, 1916..	83.3	64.8	47	27.60	78,275,000	2,836,050	78.30	93.8	27.40	77,370,000	2,823,720	2,083
July 28, 1916—Aug. 31, 1916..	81.7	59.4	65	34.83	90,825,000	2,607,660	77.32	96.2	34.77	89,640,000	2,578,090	1,937
Sept. 1, 1916—Sept. 28, 1916..	74.3	49.2	54	27.92	62,710,000	2,246,060	72.81	99.6	27.50	60,560,000	2,202,180	763
Sept. 29, 1916—Oct. 26, 1916..	65.8	40.1	47	28.00	66,800,000	2,385,710	76.37	99.8	27.79	65,895,000	2,371,180	593
Oct. 26, 1916—Nov. 30, 1916..	47.9	31.7	61	35.00	98,490,000	2,814,000	74.11	98.0	35.00	98,490,000	2,814,000	747
Totals			722	344.10	1,040,740,000				334.92	987,885,000		14,659
Averages per day........ ...					3,024,528					2,949,615		41

Whole filter in use except from Aug. 26 to Sept. 30, when 1.14 acres only were operated. Oct. 1 to 3, 0.97 acre in use.
Area of whole filter, 2.108 acres.

During the total of 344 days which the tanks have been in operation 1,040,740,000 gal. were treated, an average of 3,024,500 gal. per 24 hours. The detention period with the five tanks in use has varied from 2 hours with a rate of 10,000,000 gal. to 10 hours when the rate falls below 2,000,000 gal. in the night; with a rate of 3,000,000 gal. the detention period is 7 hours.

Although there is some settled wool scouring liquor in the sewage, the free fat content is not high, two determinations on dry weather weekly composites giving 63.0 and 64.2 parts in the crude sewage, and 32.8 and 29.8 parts in the Imhoff effluent.

Dosing Tanks—The dosing tanks were thoroughly cleaned from time to time of all growth and grease clinging to the walls and bell surfaces, and also the small amount of sludge accumulated on the bottom. As soon as the leaves began to fall the tanks were covered with planks, which remain until spring. The operation of the alternating device has been satisfactory, except for a short time in July, when it was erratic. An examination of all the connections revealed a cracked elbow. A new elbow was substituted and two auxiliary pipes removed Aug. 1. Since then the tanks have worked as intended.

Sprinkling Filter—The filter has been in operation a total of 335 days and 987,855,000 gal. have been treated. This gives an average of 2,949,600 gal. per 24 hours, or 1,399,200 gal. per acre per day, when the whole bed, 2.108 acres, is in use. From Aug. 26 until Sept. 30 eight distribution lines were shut off, leaving the 1.14 acres to treat the entire flow of 74,705,000 gal., an average of 2,176,000 gal. per 24 hours, or 1,909,000 gal. per acre per day. During this period the effluent was of good quality and non-putrescible. From Oct. 1 to 3 the portion of the bed which had not been used was operated alone and the final effluent, which appeared very brown and cloudy, was unstable. This was the only instance during the year when the methylene blue bottles lost color.

A heavy growth covered the surface of the filter during the summer; it could be peeled off readily in thick, leathery chunks, on the underside of which were bunches of small red worms and numerous threadlike white worms. Both kinds were found also on the stones beneath the surface. Although the growth was profuse, there was no pooling whatever on the filter at any time. When the filter was shut off the growth dried up and for the most part washed away when operation was resumed.

During the first week in April, when the flow was high, due to thaws, the whole filter was by-passed and the surface stones loosened to a depth of about 8 in. with picks. The odor was not dissimilar to that of a salt marsh; the stones were dirty, but after operation was resumed and the unloading began they became clean and healthy. The bulk of the unloading occurred in June.

The small white flies caused comparatively little nuisance this year, being neither numerous nor troublesome. The cold spring and abnormally wet weather in June may account for their non-appearance.

A large number of nozzles have been cleaned, but since the stop planks and scum boards on the Imhoff tanks were raised the clogging caused by sudden high flow has been largely eliminated. Matches which pass through the Imhoff tank screens constitute more than 75 per cent of the material removed. In winter growths detached from the dosing tank walls and distribution pipes cause some trouble and account for most of what few nozzles are found frozen.

Ice on the filter has not been a serious handicap to the operation. When the weather is intensely cold and the wind strong, ice appears as "nubbles" over the entire surface, but as soon as the wind dies down the bed becomes clear, except for ice "doughnuts" around the nozzles.

The crude sewage is coldest during thaws and sometimes reaches 35° F., but the air being warmer at such times there is no loss through the plant. Feb. 14 was the coldest day of the year, and temperatures taken hourly throughout the 24 hours showed the following: Air, maximum 18° F., minimum —5° F.; crude sewage, maximum 47.3° F., minimum 43.3° F., average 44.7° F.; Imhoff effluent, maximum 45.1° F., minimum 39.7° F., average 42.3° F.; sprinkling filter effluent, maximum 35.6° F., minimum 32.9° F., average 34.2° F.; final effluent, maximum 35.2° F., minimum 32.0° F., average 33.2° F. The temperature of the air the day previous was, maximum 23° F. and minimum 2° F.

A similar test during the second day of a hot spell showed: Air temperature, maximum 92° F., minimum 68° F.; crude sewage, maximum 68.4° F., minimum 65.3° F., average 67.2° F.; Imhoff effluent, maximum 69.8° F., minimum 68.0° F., average 68.6° F.; sprinkling filter effluent, maximum 73.8° F., minimum 71.2° F., average 72.4° F.; final effluent, maximum 75.2° F., minimum 71.6° F., average 73° F.

Secondary Tanks—The secondary tanks have been emptied eight times; in December, April, twice in June, July, August, September and November. Three times the contents were pumped into Imhoff tanks 1, 2 and 4, but owing to the uncertainty of the weather for sludge drying, and the fact that these three tanks were full of sludge, the piping on the pump was changed to deliver the sludge on the area south of the effluent channel and east of Falulah Road. With this arrangement the tanks were cleaned more economically and the sludge flowed readily into the low places. It caused no disagreeable odor, was hidden from sight by tall grass and bushes, and soon dried up.

A total of 163.7 tons of dry solids was intercepted by the secondary tanks; 74.3 tons were pumped to the Imhoff tanks and 89.4 tons disposed of on the area mentioned above. This total amount of solid matter was contained in 580,760 gal. of sludge, the per cent solids of which for the eight pumpings varied from 5.49 to 9.84, averaging 7.23; the specific gravity varied from 1.016 to 1.032, averaging 1.024.

The per cent of total solids which are volatile varied from 33.38 to 47.17, averaging 40.80. The power used for pumping varied greatly, depending on the amount and character of the sludge. Each tank with a total capacity of 84,500 gal. was emptied at every pumping and the tank thoroughly washed with a hose attached to a hydrant. Based on the total consumption for cleaning the tank, the power for 1,000 gal. of sludge varied from 1.6 kw. to 7.7 kw., an average of 3.1 kw.

During the extreme cold weather the tanks freeze over at night, but the ice is usually removed by an attendant on the following day, so that the tanks are kept open.

Except for the short time required for cleaning and painting, the secondary tanks have received the entire effluent from the sprinkling filter. The final effluent is well saturated with dissolved oxygen, is odorless, and more attractive in appearance than the river into which it flows.

Sludge Disposal—The 11 sludge beds, aggregating 0.42 acre, have been cleaned six times and filled six times. The first cleaning was the sludge which had remained on the bed all winter, and only a portion of this sludge, 18.4 tons dry solids, belonged to this year's record.

A total of 671,600 gal., containing 443.6 tons dry solids, was pumped onto the beds, requiring 615 kw., about 1 kw. per 1,100 gal. sludge, or 7.5 kw. per hour of pumping under normal conditions.

The average specific gravity of the sludge as it entered the bed varied in the six regular pumpings from 1.047 to 1.081, average 1.065; and the average per cent of total solids from 11.36 to 17.02, average 14.90. The average per cent of dry solids which are volatile, as determined on the sludge from the different tanks, varied from 35.85 to 39.13, average 37.55. This is considerably lower than last year and indicates a greater reduction in the solid matter due to liquefaction and gasification in the digestion chamber, since the average per cent of volatile matter in the suspended soils deposited in the tanks was even greater than last year.

The sludge as delivered to the beds had a tarry but not unpleasant odor, was strongly alkaline to lacmoid but not to phenolphthalein, and at no time caused any nuisance. In order to insure a more uniform depth on the bed it was necessary to use a large squeegee which one man can push readily along the rails of the track. The average depth for the first five pumpings varied from 8.2 to 9.5 in., average 8.9. The last pumping, Oct. 26-30, which lowered the sludge in the Imhoff tanks sufficient to care for the next six months' sewage, averaged 11.5 in., and will remain on the beds until spring. It has been found that, while a depth of 10 to 12 in. requires too long a period to dry, a depth of 8 to 9 in. requires comparatively little longer than one of 6 to 7 in. and is, therefore, more satisfactory.

The period between pumping and removal has varied from 22 days to a maximum in the case of one or two beds of 44, the average being about 30. The very wet weather in summer has made it impossible to determine in just how short a time the sludge may be handled, for in every case rain came within 48 hours after pumping. As soon as the sludge became stiff it was turned with masons' hoes, thereby hastening the drying appreciably.

Careful estimates have been made of the quantity handled and representative samples have been taken for analysis of both the wet and dried sludge. The importance of proper and frequent sampling has been demonstrated, and too much emphasis cannot be placed on this part of the work.

A total of 1,347 cu. yd. has been taken from the beds in the six cleanings. The average quantity removed per cleaning, corresponding to the first five pumpings of the year, was 218 cu. yd., and the average depth at time of removal varied from 3.5 to 4.3 in., averaging 4.0 in. Based on the average depths at time of pumping and at time of removal, the shrinkage in volume varied from 52.8 per cent to 61.7 per cent, averaging 55.9 per cent. The weight per cubic yard as hauled varied from 1,278 to 1,559 lb., average 1,415. For the first five pumpings 324.5 tons dry solids was applied and 356 tons removed, the increase of 31.5 tons, or 4 to 5 cu. yd. per cleaning, being due to adhering sand. About 6 to 8 cu. yds. of rakings in addition to the sludge is taken from the beds at every cleaning.

The sludge has been disposed of in various ways; a small amount has been carted away by farmers; some has been used for filling, some for fertilizing the shrubs, and some as top dressing on land near the works. To test its fertilizing value 1/15 acre of poor, sandy, virgin soil was planted with potatoes, using sludge only as a fertilizer. A crop of 12 bu., of good size, clean, and without a single rotten one, was harvested.

The cost per cubic yard for removing the dried sludge averaged $0.41; this includes carting and preparing the bed for the next pumping. Labor is 32 ct. per hour, team and driver 75 ct. and foreman 40 ct.

Iron Content in Illinois Water Supplies.—The iron content of the water supplies in 192 Illinois municipalities which used ground waters are classified as follows by Mr. G. C. Habermeyer, Engineer, State Water Survey of Illinois, in a paper presented before the Illinois Public Health and Welfare Association:

Number of cities.	Iron content parts per million.
22	0.0 to 0.1
62	0.1 to 0.5
32	0.5 to 1.0
45	1.0 to 2.0
19	2.0 to 4.0
12	4.0 or more

The 12 municipalities listed with supplies containing more than 4.0 parts of iron had a population of only 13,367 in 1910. The larger cities often have many wells and one or two analyses of water from a city may not represent average conditions. The iron content of the water supply of some of the larger cities of the state is about as follows:

	Part per million.
Springfield	1.0
Elgin	1.0
Freeport	0.7
Champaign and Urbana	2.0

Freeport, Ill., and Champaign, Ill., have installed iron removal plants. Waters from some of the wells at Galesburg, Ill., contain considerable iron. All other cities in Illinois larger than Champaign, including six with ground water supplies, are supplied with water containing less than 0.5 parts per million of iron.

It is estimated that the annual freight capacity of the improved Erie Canal system will be 10,000,000 tons.

USEFUL LIFE OF WATER WORKS UNITS

In connection with the preparation of its report on depreciation the American Waterworks Association Committee, consisting of John W. Alvord, chairman; Daniel W. Mead, C. B. Salmon, J. N. Hazlehurst and W. F. Wilcox, collected a large amount of data on the known useful life of waterworks units. This information is summarized in a general way as an appendix to the final report of the committee, submitted at the Richmond Convention of the Association. The following matter is taken from this report:

In fixing useful life of plant units for the purpose of amortising their cost, it is well to remember that as the public must reimburse the utility for this loss of value before the computation of fair rates can be ascertained, there is no real dispute over the matter except to get at the facts correctly. Unreasonably large depreciations make for unduly high rates. Unduly small depreciations make for insufficient revenue. No one can be permanently interested in either of these mistakes.

Among other considerations, in fixing upon probable life it is also well to remember that prudence and conservation suggest that, if anything, we underestimate life somewhat rather than overestimate it, especially in short-lived units, which cannot be readjusted from time to time. The prudent owner will never unduly magnify his future stability of plant endurance, a very common optimism which often leads to serious embarrassment, and even disaster.

It is further desirable to note that human needs even of the most fundamental kind, cannot be successfully predicted for more than a century, or at the utmost a century and a half ahead. In valuation work, it is always the future need of the public served that makes utility value, and this need must therefore be predicted as carefully as possible, but we are not warranted in predictions that are not reasonable in the light of past history.

The greater portion of the water supplies of this country have been built since 1870, a period of less than 50 years. The life of a water supply or any of its parts should not, as a matter of prudence, be estimated at too long a life; first, because it can be amortised in about a century without burden, and, second, because to predict the needs of human civilization farther than this would be to tax credulity.

With these generalizations, it is interesting to note in some detail the effect of past experience in some of the major units that enter into waterworks property on the probable future length of usefulness.

The following are the general conclusions of the committee:

Storage Reservoirs and Heavy Earthen or Masonry Dams—Large Masonry Conduits and Tunnels.—Physical: —All structures of earth or earth and masonry are very durable, and in some cases reservoirs, aqueducts, and dams have lasted thousands of years. Undoubtedly such construction well-maintained is ordinarily good for some hundreds of years, physically often far outliving their functional usefulness.

Functional:—All structures holding or conveying water are subject to accident from rupture, floods, burrowing animals, ice pressure, windstorms, leaks, insecure foundation, polluting influences, and malicious destruction.

Physical and contingent losses of value will be made good ordinarily by operating maintenance. This being thoroughly done, such structures should, in addition, be amortized about as follows:

Large storage reservoirs, well located	75-150
Heavy earthen or masonry dams	75-150
Large masonry conduits and tunnels	75-150

Conduits and Distribution Pipe of Cast Iron of Large Diameter.—Cast iron pipe coated and buried in the ground is a very durable structure. We have little knowledge of its final effective life from a physical point of view. There are some instances of 200 years' life for uncoated pipe. Largely, we must amortise such durable material, kept clean and well maintained, again by consideration of the possible changes in public need, functional usefulness, and the burden of a reasonable amortisation, say, 75-125.

Conduits and Distribution Pipe of Wrought Iron or Steel of Large Diameter.—Thickness of shell and sensitiveness to a greater range of deteriorating influences must of necessity bring the life of wrought iron and steel physically below that of cast iron, and in many cases below functional considerations, 35-75.

Conduits and Distribution Pipe of Wood Stave of Large Diameter.—Ultimate experience somewhat limited, but thought to be about in same class as steel, when well protected and constantly saturated, 30-60.

Distribution Pipe of Small Diameter.—(a) Cast Iron: Limitations of size increase difficulties in interior cleaning and maintenance. Such smaller mains are at times removed in rapidly growing cities to make way for larger pipe. Often, they are only supplemented, 30-70.

It should be noted that in slow growing and smaller cities small mains are less liable to be outgrown than in larger cities, 50-90.

(b) Wrought Iron and Steel Mains: Affected by kind of water carried, soil, and coating. Liability of replacement probably greatest influence in shortening useful life, 25-40.

(c) Services:	Wrought iron and steel	15-30
	Lead	40-60

Of services, it should be noted that character of water carried, soil, and coating are influential, but changing needs are also important.

Small Distribution Reservoirs.—Physically, these structures are very permanent. Changing needs often destroy or impair their usefulness and value; they are often surrounded by growing population and increasing land value, which, in connection with decreasing need, make it desirable to abandon them. They sometimes lose value on account of need for increased head, 50-75.

Standpipes.—Are affected by most of the influences mentioned above, and lose value in rapidly growing towns by insufficient proportional storage capacity with increased consumption. They often have value as regulators, however, long after their storage usefulness is diminished:

Wrought iron and steel	30-60
Reinforced concrete	50-60

Valves.—Valves physically should be amortised on the basis of the life of the valve body, the working parts being subject to operating maintenance. Fundamentally, they are more subject to change and improvement than the pipe in which they are set, and therefore should have shorter life, 40-60.

Hydrants.—Theoretically should have the average physical life of the hydrant body, the same as valves, but being in part exposed and more liable to accident and injury, and more often operated, may be considered to have somewhat shorter life than valves, 30-50.

Meters.—Physically they should be amortised on the basis of the life of the meter casing, the working parts being subject to renewal and repair, chargeable to operating maintenance. Fundamentally, being of delicate construction and of necessity exposed to frost, clogging, and other adverse influence and often renewed, suggested life, 20-30.

Pumping Machinery.—Pumping machine units are functionally sensitive to changes in consumption, growth of population, improvements in the art, influences affecting sources of supply, amount of use, character of water, etc., etc., and these are the conditions that ordinarily fix their useful life.

Where function does not control physical life for amortisation purposes, it should be predicated on the probable useful life of the stationary and heavier castings, all working parts being cared for annually by operating maintenance:

High duty, large units	35-60
High duty, small units (say, below 6 m.g.d. cap.)	25-40
Ordinary direct acting	20-40
Centrifugal, not geared	20-30
Centrifugal, geared	15-25

Boiler feed and auxiliary pumps usually take the life of the units to which they are attached.

Steam Engines.—About the same considerations as above, 20-40.

Boilers.—Are affected by water used, care and attention, changes in station, and changes in pressure. They may often have a long period of usefulness in reserve, 15-30.

Electric Generators and Motors.—In general, follow the reasoning on pumps, but are shorter lived, 20-30.

Filter Plants.—Now well standardized. Life should be predicated on general usefulness of station and source, as well as function of the filters themselves:

Masonry filters	30-50
Wood filters	15-30

Buildings.—Must be reviewed in the light of the probable life of the station as a whole. In rapidly growing towns they are frequently outgrown, but can often be enlarged. They lose value often in a general way because of changes in the style of architecture. Where function does not control their lives physically, it should be based on masonry walls, foundations, and roof supports; all other parts being removed from time to time by operating maintenance account:

Masonry	30-60
Wood	20-40

Stacks.—Are limited in life to conditions of power production directly; somewhat affected by style and general appearance.

Masonry	25-50
Steel	10-25

SERVICE CHARGES—HOW CONSTITUTED.

There is considerable difference of opinion as to what constitutes a service charge and the ways of determining it. The committee on Meter Rates of the New England Waterworks Association, in its report which has been appearing during the last two years in the Proceedings of the Association, states that the service is made up as follows:

First, the average amount of money invested by the works in the service pipe and meter.

Second, the cost of reading meters, keeping of meter records, making out bills and collecting the money.

Third, an amount which will represent the approximate average value to the work of the water that passes a domestic meter without being registered.

An interesting discussion of the conclusions of the committee was presented by J. N. Chester, of Chester & Fleming, consulting engineers, Pittsburgh, Pa., in a paper read at the recent meeting of the Four-State Section of the American Waterworks Association at Philadelphia. An abstract of this paper follows:

The New England Committee, in determining their ratios used in the discussion, started with areas of circles the same as meter sizes, which they tempered with the ratio of the carrying capacities, as well as the maximum normal output of meters, and, it is interesting to note, arrived at nearly the same ratios as the writer, wherein he started with the diameter of the service piping and the meter, tempered this with the normal capacity of meters, the loss of head in service pipe, meter, and orifice of influx, as shown in Table I.

The relative final results as to ratios obtained by the writer and the New England Committee were:

	New England.	The author.
½-in. service, ⅝-in. meter	....	1
¾-in. service, ⅝-in. meter	1	1.75
¾-in. meter	1.7	2
1 -in. meter	3	3.25
1½-in. meter	6	7.5
2 -in. meter	10	10
3 -in. meter	20	18.75
4 -in. meter	30	31.25
6 -in. meter	60	50

With this ratio established, the New England Committee proceeded to build up the service charge for a ⅝-in. meter as follows:

First: 10 per cent of the average investment of the works in the service pipe and meter.

Second: $1 per annum for reading meters, billing, and collecting.

Third: $2 per annuam for the probable value of unregistered water.

For a domestic service charge with ⅝-in. meter the ordinary service charge may properly be $3 when the service and meter are paid for by the taker; $4 when the meter is furnished by the works, and $5 or $6 where both meter and service pipe are paid for by the works, the lower figure being used where the average cost of the service pipe is under $15 and the higher where it is greater than $15.

The service charge for larger size meters naturally is obtained by multiplying that found for the ⅝-in. by the factors above given.

In the writer's opinion, the New England Committee has established but a portion of the service charge which might, with the exception of unregistered water, properly be styled the consumer charge, and he believes the service charge should be constituted of a consumer charge and a capacity charge, and that unregistered water should be accounted for in the output charge.

The consumer's charge he would define as being made up of the cost which accrues to the plant due to each separate consumer, such as reading meter, repairing the meter and service line if owned by the utility, interest on the meter and service line, the keeping of accounts and making out, mailing and collecting bills.

The capacity charge should in total for all consumers, including public and private fire protection, be the amount necessary to keep the plant ready for service and intact, were not a drop of water delivered for the entire year, necessarily including interest on the fair investment and depreciation on the entire physical plant.

The cost of producing service, together with maintenance and profits, should be incorporated in the output charge.

Whether we constitute the service charge of one thing or another, and regardless of what elements may enter into this make-up, the burden of this paper is to argue and show, if possible, that the amounts set forth in the report of the New England Committee as ordinary proper service charges are inadequate, except in extreme cases, or, at the best represent possible minimum amounts applicable in extraordinary cases only.

A reply to the above may be that whatever the service charge produces, the balance must be made up by the output charge, which of course is the intention of any service charge, but we believe the New England Committee has neglected the fact that in many places the revenue from output charge is extremely variable and unstable, and unless it becomes the major source of revenue, it will too frequently occur, due to the ups and downs of prosperity, wet seasons and other causes too numerous to mention, that the revenue will become inadequate to meet the requirements expected of it.

Let it therefore be understood that, in the writer's opinion, the function of the service charge is more to stabilize, than to produce a revenue, which might all come from an output charge, if revenue so obtained was from year to year stable.

Fire Protection.—Public: We have told you previously in this paper that the service charge included public fire protection, but that the rate for same may be fixed by any of the methods above discussed, we do not contend, but shall pass this subject with the one suggestion that whatever the method of determining what the amount of public

TABLE I. RELATIVE DEMAND OF SERVICE LINES AND METERS.

Service lines assumed at 100 ft. long from street main to center of maximum demand.

Diameter of service pipe	½"	¾"	¾"	1"	1½"	2"	3"	4"	6"
Size of meter	⅝"	⅝"	¾"	1"	1½"	2"	3"	4"	6"
Type of meter		Disc Meters.					Rotary Meters.		
Capacity in gals. per min.	4	7	8	13	30	40	75	125	200
Capacity in gals., 24 hrs.	5,760	10,080	11,520	18,720	43,200	57,600	108,000	180,000	288,000
Loss of head in feet:	27.00	19.00	25.00	19.00	11.00	6.60	2.92	1.85	.58
Service pipe									
Meter	7.00	16.00	3.00	2.30	5.00	6.00	8.07	7.00	4.60
Orifice of influx	.34	.20	.27	.22	.23	.13	.09	.07	.04
Total loss of head	34.34	35.20	28.27	21.52	16.23	12.73	11.08	8.92	5.22
Relative demand	1	1.75	2	3.25	7.5	10	18.75	31.25	50

fire protection shall be, that it shall place the proper proportion of that burden on the vacant lot, as well as the improved property, encourage the installation of a sufficient number of hydrants and prevent in the instance of privately owned plants the ordering by the municipality served of long lines of pipe without compensation.

Private.—It is the writer's opinion that the service charge should cover private fire protection only to such extent as the hazard thereby incurred to the water company shall warrant, the excess over and above this being distributed to a per sprinkler head, per hydrant or per nozzle charge, and we hope to see the day when this charge shall be tempered by the hazard.

Output Charge.—The output charge may be defined as that part of the burden due to the cost of operating the plant, which includes fuel, supplies, maintenance, other than depreciation, and salaries to more or less extent in controversy; and the oft repeated statement that the proper return having been obtained through service charge, the entire output may be sold at a fixed price unit, is, in our opinion, in nine cases out of ten, a fallacy, permissible only in districts where consumers are wholly residents or domestic, and even then open to question; for consider, the nearer you can group your consumers to the pumping station, the lower the cost at which they can be served. This would argue zone system of charges, varying with each foot the consumer is distant from the means of introducing the water into the mains. Again, each consumer that resides higher than the lowest consumer costs the water company more to produce the pressure necessary to render him good service, so again the rate should increase with every increase in elevation above the means of introducing the water into the distributing system.

Such refinement, however, would introduce endless complications, and so common practice has ordinarily decreed that within a certain district all consumers supplied by one pressure at the source or means of introducing water to the distributing system shall be accorded the same rate.

In the output charge as we have above intimated, a variation should be made and in which, in most cases, quantity consumed should govern price per unit of service.

To forestall attacks from the advocate of the principle that no water should be sold below cost, let us say that in our opinion cost is susceptible of different interpretations and should be looked upon from the standpoint that a large consumer is profitable at any rate which produces a result that will add to the net revenue of the plant, even though the rate is below the average cost as built up by administration, operating, depreciation, interest and profit.

The principle adopted by many rate makers of first determining the high or unit price for small quantities to small consumers is, in my opinion, wrong, and that the minimum output unit price or charge to the largest consumer should be first determined, and the following are a few axioms observed by the writer in casting output charges:

A community with few or no industrial consumers may have but a single output charge.

Communities where a water supply is universally accessible to large consumers demand either a high service charge or the extremely variable output charge.

In casting a variable output charge the lowest unit price should be the maximum that conditions will permit, and the higher you make the low price, the lower you may make the high price.

Usually a railroad or some large mill or factory is the consumer to receive the low price, and his ability to produce his own supply and the cost at which he can obtain it is not only the feature that must govern as to whether or not he is a consumer, but at what price the company or municipality can afford to furnish him a supply, which equitably should be a trifle more than the unit price at which he could provide his own. Once this low price is fixed, the next larger consumers generally give less trouble, and the probable revenue from large consumers is soon ascertained and subtracted from the whole amount to be derived from output charge, the remainder can be distributed to the commercial and domestic or small consumers in a consistent manner.

A few recently adjudicated service and output charges will serve to illustrate.

Size of opening.	‡Beaver Valley, Pa.	City Water Company, Sedalia, Mo.	Ohio Valley Water Company, Bellevue.
*½-in. or ⅝-in. tap	$ 4.60	......	......
†½-in. or ⅝-in. tap	9.00	$ 6.00	$ 6.00
½-in. or ¾-in. tap	13.00	9.60	9.00
½-in. or 1-in. tap	24.00	12.00	17.00
½-in. or 1½-in. tap	48.00	30.00	30.00
1¼-in. tap	......	18.00	......
½-in. or 2-in. tap	100.00	48.00	50.00
½-in. or 3-in. tap	200.00	90.00	110.00
½-in. or 4-in. tap	380.00	120.00	200.00
5-in. tap	......	168.00	......
½-in. or 6-in. tap	810.00	240.00	440.00

*One opening only. †More than one opening. ‡Based on diameter of tap in main.

Output Charge.

Beaver Valley:
For the first 1,000,000 gal. per annum, 10c per 1,000 gal.
For the next 9,000,000 gal. per annum, 8c per 1,000 gal.
For all over 10,000,000 gal. per annum, 6c per 1,000 gal.

City Water Company, Sedalia, Mo.:
For the first 30,000 gal. per month, 30c per 1,000 gal.
For the next 100,000 gal. per month, 20c per 1,000 gal.
For the next 200,000 gal. per month, 15c per 1,000 gal.
For the next 1,000,000 gal. per month, 10c per 1,000 gal.
For all over 1,330,000 gal. per month, 7.5c per 1,000 gal.

Ohio Valley:
For all water used 12c per 1,000 gal.

The decision in the Ohio Valley Case outlined the following:

Fair return, 7 per cent	$ 64,732.08
Annual operating expenses	63,500.00
Annual depreciation, [illegible] of 1 per cent	6,935.58
Gross revenue	$135,167.66

This gross revenue to be collected by the company as follows:

From fire service	$ 27,035.53
From all other service	108,134.13

This last item was to be the product of the service and the output charge, which, strange to say, applied to 1916 conditions, produced the following:

Output charge	$ 59,319.48
Service charge	40,824.23
Total	$100,143.71

or nearly $8,000 short of prediction, and it might be also noted that it divides the revenue, other than fire protection, at approximately 60 per cent from output and 40 per cent from service charge.

The Beaver Valley rates were cast to produce a gross revenue of $135,950, of which $25,000 was set apart for public fire protection, and the remaining $110,950 was ordered distributed—60 per cent for ready to serve and 40 per cent for output.

A comparison between the ready-to-serve charge and private fire protection rates for different size opening imposed by the Beaver Valley decision is as follows:

	Domestic.	Fire.
1½-in.	$ 48.00	$ 50.00
2-in.	100.00	75.00
4-in.	380.00	100.00
6-in.	810.00	175.00
8-in.	......	300.00

Sedalia, Mo., is a city where water is difficult to obtain. They have but two large industrials, namely, the shops of two railroads centering there.

Rubber Hose for Coagulant Piping at Filtration Plant.—Trouble due to clogging of the pipe carrying the alum solution to the coagulant basins of the Rock Island, Ill., filter plant were eliminated by replacing the old pipe with 4-ply rubber hose installed in 50-ft. lengths. Whenever the hose clogged up it was removed one length at a time, trod upon to loosen the deposits and then flushed out with water under pressure.

The Imperial Valley Irrigation District of El Centro, Cal., has authorized a $2,500,000 bond issue. Of this amount $1,500,000 will be expended this year for construction work, that will bring 50,000 additional acres under irrigation.

CITY SUPPLIES WATER FOR IRRIGATION OF TRUCK GARDENS.

The city of Bridgeton, N. J., is supplying water from city mains for 19 irrigation plants ranging from ½ to 1 acre in size, and for 13 small plants of from 100 to 200 ft. overhead pipe. The city furnishes the water on a flat rate. The minimum annual price of water for irrigation purposes, on payment of which 250 lin. ft. of overhead pipe may be used, is $5. For each foot of overhead pipe in excess of 250 ft. an annual price of 2 ct. is charged.

The overhead system of irrigation is in extensive use at Bridgeton. One of the largest installations in this country is located there. This is the Seabrook Farm Co., a $250,000 corporation, which is cultivating 100 acres in this way. This company, however, has its own water supply.

The truck farms supplied with water by the city are small, but are bringing in excellent profits for their owners, as indicated by the following extracts from an article in the New York Tribune:

Mr. John S. Ware, secretary and treasurer of the Cumberland Trust Co., began his experiment in intensive cultivation three years ago. His principal purpose at first was to demonstrate the truth of a theory he held—that any industrious man could make a living off one acre of ground. His first step was to hire a man with a practical knowledge of gardening, at $12 a week the year around.

During the first year Mr. Ware had under cultivation less than half an acre—a piece of ground in the rear of his dwelling. He put up irrigation pipes, at a cost of about $200, and covered the ground very heavily with manure, using about 40 or 50 tons. Also, he used a large amount of other fertilizer, including about a ton of bone. His purpose was to get the ground into excellent shape for raising a big crop the next year.

The first year Mr. Ware planted his little tract in lettuce, celery and tomatoes. He was rewarded with crops above the average; but because of the initial expense of installing his irrigation plant and fertilizing the ground and because his charge of $624 for labor during the year was unusually large he faced a deficit of about $500.

The second year Mr. Ware extended his little farm to a full acre. In the busiest seasons in spring and fall he hired four other men by the day to help his gardener. His crops were more than twice as large as they had been the preceding year. His total expenditures for the year were approximately $1,200, and from this one acre he raised and sold produce of an equal value, breaking even financially. These figures, however, are exclusive of considerable quantities of produce used by Mr. Ware and the families of his friends during the year. Moreover, by being more conservative on many items of expenditures he could have made a comfortable profit for the year, in spite of the failure of his onion crop because of too much rain, which cost him several hundred dollars.

Last year, cultivating 1⅛ acres of ground, Mr. Ware made a net profit of $724.14, in spite of extra expense involved in extending his irrigation system. This season he will cultivate 1½ acres and expects to clear a net profit of at least $1,500.

Mr. Ware's gross receipts for 1916 were $2,101.60. His expenses came to $1,377.46. An itemized account of his approximate expenditures during the year is as follows:

Manure	$ 150.00
Other fertilizer	100.00
Gardener's wages	624.00
Extra labor	150.00
Shipping expenses	100.00
Water	30.00
Miscellaneous	223.46
Total	$1,377.46

The various crops which Mr. Ware raised on his one-acre farm, with the approximate amounts he received for each, were as follows:

Lettuce	$ 700
Celery	500
Tomatoes	300
Strawberries	100
Onions	200
Beets, carrots, radishes and peppers	300
Approximately	$2,100

Probably the most exceptional success achieved by the city farmers in Bridgeton is that of John P. Marts, who was two years ago a working glassblower in a Bridgeton factory, and is now the landlord of 3 irrigated acres in the town, from which he expects this year to reap a net profit of at least $5,000. Last year he cleared $2,000 net from one acre. This profit, however, allows nothing for his own labor.

When Bridgeton's glass factory closed 2½ years ago and Marts lost his job he took his little savings and invested them in an acre or two of Bridgeton ground.

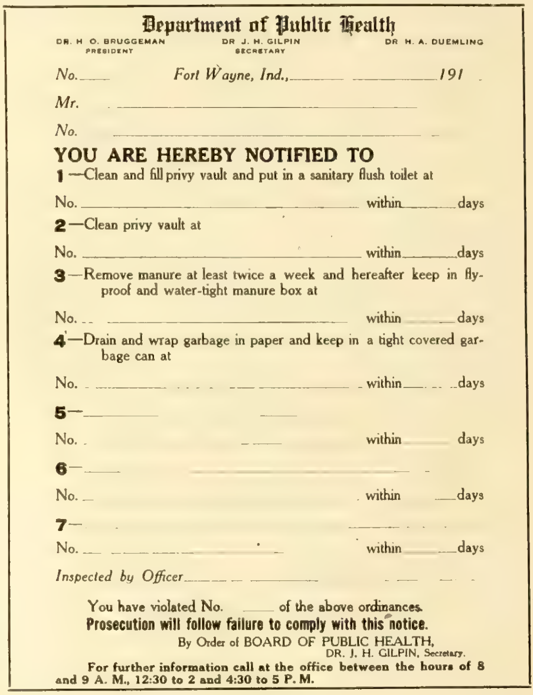
So little did Marts know of farming that he had to be taught the simple operation of planting corn. The results of his first year were discouraging. He was scarcely able to eke a living out of his one acre. But in 1916 the fertilization of the ground during the preceding year showed its effect in bumper crops, and Marts' $2,000 profit was the result.

One of Marts' principal products is lettuce. He gets two crops a year—one in the spring and one in the fall, amounting to 63,000 heads an acre. Other one-acre farmers in Bridgeton are doing proportionately well through irrigation.

HOW FORT WAYNE, IND., ABOLISHED 3,000 PRIVY VAULTS.

The Department of Public Health of Fort Wayne, Ind., a city of 70,000 population, has accomplished in a short period the noteworthy feat of abolishing 3,000 privy vaults without a prosecution and with very few objectants. These vaults have all been abolished and proper toilet facilities installed in the houses. The Department also allowed the people to put in the so-called frost-proof toilets in their back yards. These are automatic flushers, the same as are put in the residences. This was allowed for two reasons. First, it accomplished from a sanitary standpoint all that could be required. Secondly, it could be done much cheaper, especially for the smaller houses, where an addition would have to be built to the house.

As an entering wedge the Department had a city ordinance passed which provided for the abolishing of all privy vaults within 50 ft. of a residence. After working under the ordinance for a few months, the benefits that had been obtained were brought to the attention of the Common Council, which passed another ordinance making all vaults in the city a nuisance. The Department has since proceeded under this ordinance. The main features of this ordinance are as follows:



Department of Public Health

DR. H. O. BRUGGEMAN, PRESIDENT
DR. J. H. GILPIN, SECRETARY
DR. H. A. DUEMLING

No. ____ *Fort Wayne, Ind.,* ____ ____ *191* ___

Mr. ____

No. ____

YOU ARE HEREBY NOTIFIED TO

1—Clean and fill privy vault and put in a sanitary flush toilet at

No. ____ within ____ days

2—Clean privy vault at

No. ____ within ____ days

3—Remove manure at least twice a week and hereafter keep in fly-proof and water-tight manure box at

No. ____ within ____ days

4—Drain and wrap garbage in paper and keep in a tight covered garbage can at

No. ____ within ____ days

5— ____

No. ____ within ____ days

6— ____

No. ____ within ____ days

7— ____

No. ____ within ____ days

Inspected by Officer ____

You have violated No. ____ of the above ordinances.

Prosecution will follow failure to comply with this notice.

By Order of BOARD OF PUBLIC HEALTH,
DR. J. H. GILPIN, Secretary.

For further information call at the office between the hours of 8 and 9 A. M., 12:30 to 2 and 4:30 to 5 P. M.

Notification Form Used by Fort Wayne Department of Public Health.

GENERAL ORDINANCE NO. 737.

An ordinance prohibiting privy vaults and providing a penalty for its violation.

Section 1. Be it ordained by the Common Council of the City of Fort Wayne, Ind., That no person, firm or corporation shall construct, or cause to be constructed, or allow or permit to be constructed on his or its real estate, within the limits of said city, any privy vault, or use or allow to be used on his or its real estate, any vault as a privy vault, unless the same shall be directly, or indirectly by lateral drain, connected with a public sewer and unless the same is equipped with a flushing device so installed as to allow the flushing of such vault at all times and whenever used.

Sec. 2. That all existing privy vaults not so equipped and constructed as in section one (1) provided shall be emptied, cleaned and filled not later than Nov. 1, 1916.

Sec. 3. That this ordinance shall not apply to privy vaults constructed on real estate which does not abut upon a street or alley in which there is a public sewer or a lateral drain and City water for flushing purposes.

Sec. 4. Any person, firm or corporation failing to comply with or violating this ordinance shall be fined not less than five dollars ($5.00) nor more than one hundred dollars ($100.00).

The work of doing away with the privies was not arbitrarily rushed. It was known that these vaults could not be removed in one or two years; consequently, when after serving a notice to the property owner to eliminate the vault within 30 days, if he would ask for an extension of time and furnish a reasonable excuse, such as pavement, sewer or sidewalk assessments, the Department would extend the time another 60 or 90 days, thus gaining the good will of that person.

The city was divided into 77 districts of purely arbitrary boundary lines, and all the vaults in each district listed. A notice was then served on the people, and at the expiration of the time specified in the notice an inspector would reinspect the district, recording all completed and uncompleted jobs, and would notify them once again, giving a shorter time than in the original notice.

A complete survey of the whole city has not been made as yet, but it is estimated that there are in the neighborhood of 1,500 vaults remaining.

The present Department of Public Health of Fort Wayne consists of Dr. H. O. Bruggeman, President; Dr. J. H. Gilpin, Secretary and Health Officer; Dr. H. A. Duemling, Vice-President, and Anne K. Sullivan, Clerk.

PRODUCTION OF ALCOHOL FROM GARBAGE.

Experiments conducted at the garbage reduction plant of Columbus, O., indicate that alcohol of satisfactory quality can be produced from garbage, according to a report submitted last month to the City Council by Charles P. Hoover, chemist of the city filtration plant, and Thomas D. Banks, superintendent of the garbage plant. The experiments were made with the process patented by Dr. J. J. Morgan, Chicago, Ill. (U. S. Patent No. 1,114,017), and were carried out at a special experimental plant built by the city and placed in operation last December. The following extracts from the Hoover-Banks report show the methods followed:

The garbage is first weighed, 1,000 lb. being used in most of the tests, and is then charged into the digester; from 2 per cent to 4 per cent of 60° sulphuric acid is added; the acidulated garbage is then cooked under 60 lb. pressure for two hours; it is then partially neutralized with limestone and discharged into the screw press. The liquor is discharged from the press into the neutralizing tank, and the solids from the press are dried, percolated and made into tankage.

Grease is first separated from liquor and the liquor is then neutralized in the neutralizing tank with caustic or hydrated lime. This neutralization causes quite a precipitate to be formed, which settles to the bottom of the neutralizing tank or sludge compartment. This sludge is drawn off, dried and made into tankage.

The neutralized liquor is cooled by passing through a coil tube surrounded by cold water, and is then discharged into the fermenters. Yeast is then added and the liquor is allowed to ferment for from 36 to 72 hours. When fermentation is complete the liquor is pumped into the fermented liquor storage tank.

Distillation is the next step in the process. Cold liquor from the storage tank flows into the tubes of the preheater, and is heated by hot alcoholic vapors surrounding the tubes. From the heater the warmed liquor flows to the still itself, entering at a point one-fourth down from the top; here it meets an ascending current of steam, which extracts the alcohol from the liquor. The liquor trickles slowly down from chamber to chamber, and is finally discharged at the bottom as spent slop. The alcohol, however, rises with the steam through the five rectifying chambers, where its concentration is greatly increased, and passes out of the top of the column to the preheater, where it is partially cooled and thereby further concentrated and purified. From the heater the alcoholic vapors pass to the condenser, where they are condensed into a liquid and received in suitable containers.

The results of 24 experiments showed that one ton of green garbage yielded on an average of 4.55 gal. of 95 per cent alcohol, or based on 90 per cent the average yield was 4.8 gal. per ton of green garbage. All calculations are based on this average. The alcohol yields per ton of garbage varied considerably and the results were very irregular. This irregularity is largely ascribed to the great variation of the sugar content of the liquor that is obtained from the garbage.

The following tables from the report show some of the results obtained from experimentation:

Estimated revenue and cost of operation, using present war prices.
Alcohol yield taken at 4.80 gals. 180 proof alcohol per ton of garbage. 20,000 tons garbage per year.
Revenue.
4.80 gal. alcohol at 70 ct. = $3.36 per ton garbage, or $67,200.00.

Total operating costs, estimated	$40,260.00
Cost per ton garbage	2.01
Cost per gallon alcohol	.42
Profit per ton garbage	1.34
Profit per gallon alcohol	.28
Annual profit	26,940.00

Return on investment, 75 per cent.

Estimated revenue and cost of operation based on average prices prevailing during normal times:
Revenue.
4.80 gal. alcohol at 35 ct. = $1.68 per ton garbage, or $33,600.00.

Total operating costs, estimated	$29,260.00
Cost per ton of garbage	1.463
Cost per gallon alcohol	0.305
Profit per ton garbage	0.217
Profit per gallon alcohol	0.045
Annual profit	4,340.00

Return on investment, 12 per cent.

Effect on Grease Production.—A special test was made in order to compare the results of the Morgan alcohol process with the results secured by the regular process in operation at the plant, with respect to the yield of grease and tankage, particularly the latter.

Two portions of garbage, 1,000 lb. each, were carefully weighed. One sample was treated in accordance with the general practice now followed at the garbage plant and the other sample was treated by the Morgan alcohol process. The yields and analysis of tankage produced are shown as follows:

	Regular Process.	Morgan Process.
Pounds grease recovered	66.68	62.32
Pounds tankage recovered	164.50	162.00
Gallons of 90 per cent alcohol recovered		5.80
Analysis of tankage (per cent)—		
Ammonia (NH_3)	3.63	3.26
Potash (K_2O)	2.01	2.16
Tri-calcium phosphate $Ca_3(PO_4)_2$	4.94	4.46
Value grease recovered	$5.01	$4.69
Value tankage recovered	1.76	1.62
Combined value of grease and tankage	6.77	6.31
Value of alcohol at 70 ct. gal.		4.06
Total value of all products	$6.77	$10.37

All figures are per ton garbage.

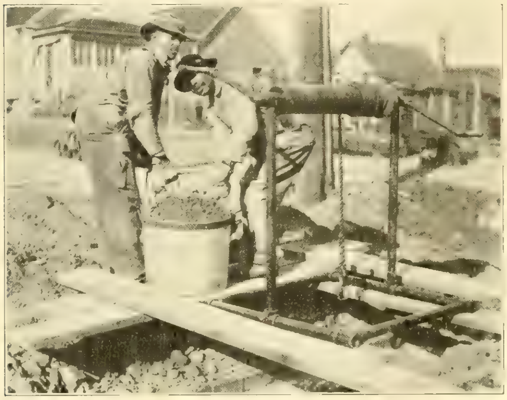
The results shown in the above table indicate that grease and tankage yields are not as high by the Morgan process as by the regular process. Not much dependence, however, states the report, should be placed on the results from this one test, because of the variable nature of the material such as garbage, and the difference found might be accounted for by the method of sampling.

CLEANING PIPE LINE COATED WITH METALLIC SLIME.

The effect of cleaning 9,600 ft. of 24-in. force main at Lowell, Mass., that for years had carried water heavily charged with iron and manganese was described by Frank S. Barbour, Consulting Engineer, Boston, Mass., in a paper presented at the Richmond Convention of the American Water Works Association. This pipe, laid in 1896, had carried for years the metal-laden well water, and the friction loss had become so great that in 1914 cleaning was recommended. Tests in May, 1914, with rates of discharge—measured by pump displacement—varying from 4.5 to 6.0 m.g.d., made by tapping three mercury columns in the pipe at distances of 2,500 and 3,600 ft. apart, showed values of "C" in the H. & W. formula ranging from 56.5 to 58.0. The pipe when opened was found to be coated with a heavy, smooth, metallic slime, varying in thickness from ¼ in. at the top to ½ in. or more at the bottom of the pipe, but without marked incrustation or roughness of surface. The main was cleaned in September by the National Water Main Cleaning Co. and a test made immediately after the cleaning, in the same way as the earlier test, showed for rates of discharge varying from 4.5 to 6 m.g.d. values of "C" ranging from 124.0 to 127.0. Unfortunately, however, before the purification plant was completed the pipe had rapidly become dirty and the value of "C" was found to approximate 85 in November, 1915. The capacity of a soft slime to greatly increase frictional resistance is the interesting condition in the foregoing experience; it is not intended to suggest that where loss of head is due to incrustation the effect of cleaning would so rapidly disappear.

A LIGHT, EASY RUNNING WINDLASS.

A windlass having many features that make it of especial value to contractors is illustrated below. The principal advantages of the equipment, summarized briefly, are: The drum rolls on roller bearings; the handle does not slide or roll in the hand while pulling, but turns on an inner handle, thus eliminating much friction; the frame is made of standard pipe and is so light that one man can carry the complete outfit; the drum lifts out of the frame uprights, enabling the dirt to be taken out on either side of the trench without taking off the rope or turning around the frame.



Torson Roller Bearing Windlass on Trench Work at Kansas City, Kan.

The windlasses are made in two types, "one man" and "two man." The first type is best adapted to narrow trench and to shaft and tunnel work. It has, however, been used to good advantage on 5-ft. to 7-ft. wide trenches. The buckets used with this type hold 1½ cu. ft. of dirt, and it is stated that one man on the windlass can easily handle the excavation of two bottom men in ordinary digging. The "two-men" type has an extra handle and is equipped with 2¾ cu. ft. buckets. It is especially adapted for large open trench work. By unscrewing one handle and using smaller buckets, it can be used as a "one-man" machine.

The buckets furnished with the windlasses are strong and light and easy to clean. They have special bracing that allows them to be dumped hard when in muddy digging without denting the bucket.

These machines are known as the Torson roller bearing windlasses. They are being placed on the market by Martin G. Torson, Kansas City, Kan.

LEAKAGE FROM WATER MAINS AT WASHINGTON, D. C.

During the fiscal year ending June 30, 1916, the water survey division of the Water Department of the District of Columbia discovered and stopped 1,981,600 gal. daily of underground leakage. This represents the loss daily through 420 separate leaks, averaging 4,700 gal. per day each. The most fruitful source of leakage was found in the calked lead joints of the small service mains, a total of 101 cases, discharging 607,350 gal. daily, being found. One hundred and thirteen corroded iron services, discharging 449,440 gal. daily, represent the second important source. Wiped joints, wasting 342,490 gal. daily; broken lead and pewter services, 201,380 gal.; broken cast-iron mains, 142,800 gal.; and defective screw couplings, unions, etc., discharging 115,450 gal. daily, are named in quantitative order as fruitful sources of underground waste. The full statement of the nature of the various leaks is as follows:

Class.	No.	Gallons per day.
Abandoned services, taps, etc.	4	68,700
Iron services	113	449,440
Lead services	11	201,380
Wiped joints	70	342,480
Couplings	63	115,450
Stopcocks	15	28,700
Joints on mains	101	607,350
Broken mains	4	142,800
Valves	3	3,300
Blow-offs	1	8,600
Fire hydrants	1	13,400
Total	420	1,981,600

According to the report of Paul Lanham, Engineer of the Water Survey, from which these notes are taken, the leaks on the calked joints were due in most cases to the insufficient quantity of lead used previously with a false idea of economy. With sufficient lead a calked joint is wonderfully flexible, as determined by recent tests, but with the old joints, where the quantity of lead was stinted, the slightest deflection of the pipe, due to settlement or other causes, serves to open a crevice through which loss takes place. The small number of defective joints found on all recent pipe installation work furnishes ample verification of this point. The corrosion of the wrought-iron service pipes is taking place rapidly and leaks from this source will continue in occurrence for years to come. Provision of the plumbing regulations prohibits the repair of these pipes under improved pavements, and this results in the abandonment of many of them. A vast quantity of this class of pipe in the ground will not be abandoned, however, for many years, and in the meantime must be kept under constant surveillance. The leaks in the wiped joints on lead services and on lead connections to iron services represent a class somewhat different from the others mentioned, in that a number of the leaks due to them is found on the work of recent date of the highest class, and where quality apparently was not sacrificed for economy. This situation calls for an arraignment of the wiped joint as an underground connection, and the question of whether this type of joint should be abandoned for some other calls for an investigation. The leaks on the lead services can be traced in most instances to the light weight of the pipe previously used. The present regulations specify a heavy weight pipe, which seems to be perfectly satisfactory, and provision is carried prohibiting the repair of the old light weight lead pipe, which is proving unadapted to modern conditions. This is gradually bringing about the weeding out of this pipe, but the process is necessarily slow. The breaks in cast-iron mains in most cases were due to the defective workmanship on the old pipe. The modern pipe now used by the department is practically free from breakage, except where due to severe stress conditions which can not be foreseen or provided against.

PERSONALS.

D. M. Faries has been appointed City Engineer of Wallace, Idaho.

Edmund B. Ulrich has been re-elected city engineer of Reading, Pa.

C. E. Johnson has been appointed city engineer of San Bernardino, Cal.

Wallace Treichler has been re-elected City Engineer of Rock Island, Ill.

E. R. Gray has been appointed City Engineer and Manager of Waterworks of Hamilton, Ont.

George A. Reed, formerly City Engineer of Barre, Vt., has been appointed Assistant State Engineer of Vermont.

John T. Nagel has been appointed chief engineer of the Louisiana & Pine Bluff R. R., with headquarters at Huttig, Ark.

E. Ringer, formerly engineer of maintenance of way of the Missouri, Kansas & Texas Ry., has been appointed chief engineer, to succeed L. F. Lonnbladh, resigned.

J. H. Reinholdt, heretofore principal assistant engineer of the Minneapolis & St. Louis, R. R., has been appointed chief engineer to succeed R. G. Kenly, promoted.

Dudley T. Corning, heretofore assistant engineer, bureau of highways and street cleaning, Philadelphia, has been appointed division engineer in the newly created bureau of street cleaning.

W. C. Baisinger, heretofore division engineer of Atchison, Topeka & Santa Fe Ry., at Marceline, Mo., has been appointed assistant engineer in the construction department, a newly created position, with headquarters at Chicago.

Frank L. Raschig, engineer in charge of the division of structures of the engineering department of the City of Cincinnati, O., has been appointed principal assistant engineer by Frank S. Krug, chief engineer of the Rapid Transit Commission, and will prepare plans for the rapid transit system to be built by the city.

Dirt Mover and Pit Owner Issue
of

Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

First Wednesday Each Month............Roads and Streets......$1 Yearly
Second Wednesday Each Month, Waterworks and Hydraulics.......$1 Yearly
Third Wednesday Each Month....Dirt Mover and Pit Owner......$1 Yearly
Fourth Wednesday Each Month.....Buildings and Structures......$1 Yearly
Fifth Wednesday.......Planning and Management Quarterly...25 cts. Yearly
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Contract News Appears in All Issues

Volume XLVII. CHICAGO, ILL., JUNE 20, 1917. Number 25.

HIGH PRICES NO REASON FOR CONSTRUCTION CURTAILMENT, ACCORDING TO SCHWAB.

Perhaps the most important duty of engineers at present is to study carefully the probable duration of the present era of high prices, for upon the advice of engineers will largely depend the extent to which construction programs will be curtailed or expanded. Offhand it seems probable to most men that there will be a marked fall in the general level of prices as soon as the war ends. If this is to occur and if the war is to end soon, it may be wise to reduce some construction programs. But let us be quite sure of our premise that average prices will drop after the war before we adopt a policy of curtailment.

In a recent address "the great iron master," Charles M. Schwab, said:

> Let me tell you something of the experience of the Bethlehem Steel Co. Last year we entered upon a constructive program involving expenditure for the next few years of about $100,000,000. Many of our friends urged us to go slowly and wait until all costs should be reduced. But we believed that when facilities were needed they ought to be provided, and that a manufacturer should not speculate upon what he might be able to do in the future. He should do it now. That was the largest construction undertaking, I believe, ever entered upon by a single corporation.
>
> Costs are very much higher now than they were then. They promise to be very much higher in the future. But by beginning when we did we were able to greatly increase our facilities, so that they are available now when they are so supremely needed in the interests of national defense.
>
> Bethlehem Steel is today putting $20,000,000 into plants entirely for the use of the Government.

It will be noted that this executive of recognized foresight and courage had to overcome the objections of his associates a year ago when he wanted to embark on a large construction program. To his associates a hundred million dollars for new plants looked like an unwise investment to make during an "era of high prices." But to Schwab it was apparent that prices would not soon recede and would probably go higher. Moreover—and note the general significance of this—Schwab regarded it as a public duty to enlarge his plant, regardless of the personal profit that might or might not accrue.

Shall civil engineers, also charged with public duty, show more timidity than such industrial captains as Charles M. Schwab? Shall civil engineers haggle over contract prices for public works and advise curtailment of construction programs in the very hours that the country keenly needs the best and most of every kind of public plant—railways, roads, streets, sewers, waterworks, what not?

There are some engineers who are acting with less breadth of vision, less courage, and, we fear, less ordinary common sense than are to be expected of educated men. They are not even studying the industrial history of our civil war, which has thus far paralleled the history of this war in most respects.

Our civil war gave a remarkable impetus to production and coincidently it caused a great rise in prices and wages. It was followed by eight years of high prices—until the panic of '73—and wages never receded, except in spots and temporarily.

The great war now in progress is disabling and killing millions of men, very many of whom would have normally emigrated to America. Even more effective as a deterrent to emigration will be the higher wages that the war has caused in Europe. That European wages will not fall after the war seems certain, for the workmen are earning them as a result of their greater productivity.

No future economic condition is more assured than that wages will not recede after the war, both in America and in Europe. Indeed it seems more probable that they will continue to rise indefinitely. If this is likely—and leaders like Schwab think so—where is the logic in the reasoning of civil engineers who advise restriction in construction on the ground of present high prices?

Steel, it is true, has reached a price from which it is likely to decline; but when one reflects to what a small extent the price of steel affects most civil engineering works, it is clear that even a great drop in steel prices will have only a minor effect on the average cost of public works.

Let civil engineers now, if ever, give evidence both of the faith that is in them as to our economic future and of the broad knowledge of economic conditions that they are presumed to possess.

ENGINEERING STUDENTS ADVISED TO COMPLETE THEIR COURSES.

This journal was the first, we believe, to point out the advisability of having engineering students complete their courses in spite of the war. We are glad to note the college educators who met May 5 in Washington at the call of the Advisory Council of National Defense resolved that:

> We therefore believe, first that all young men below the age of liability to the selective draft and those not recommended for special service who can avail themselves of the opportunities offered by our colleges should be urged to do so in order that they may be able to render the most effective service, both during the full period of the war and in the trying times which will follow its close.
>
> In view of the serious need in the near future for men broadly educated, capable of solving the great problems, we believe that students in our colleges of liberal arts and sciences should continue where possible throughout the course of study, and that all young men who can avail themselves of the opportunities offered by our colleges should be urged to enter.
>
> We believe further that in consideration of the importance of applied science in the present war, students pursuing technical courses such as medicine, chemistry, agriculture and engineering are rendering or are to render through the continuance of their training a service equally valuable as those they might offer if they were to enroll in military or naval service.

This last paragraph is particularly worthy of note. The partly educated engineer is of little use to society as an engineer, perhaps of less use than an uneducated but strong laborer, and this is even more evident in war time than in time of peace. Not only should college educators continue to advise engineering students to finish their courses, but they should go a step farther. They should urge the wisdom of exempting engineering students from draft for military service. Such students should be given special courses in military engineering and should devote a considerable part of each day to physical training under military direction. Let the West Point method be applied rigorously in all our engineering colleges.

Incidentally we may ask, What are the engineering colleges doing or planning to do to recruit the incoming classes? Some real publicity work will be required in order to prevent an abnormal decrease in the freshman classes next fall.

CONTRACTS AWARDED ON A PERCENTAGE BASIS FOR ARMY CAMPS—AN OPPORTUNITY FOR SUB-CONTRACTORS.

Thus far five firms of engineering contractors have been awarded contracts for army cantonments, namely: Fred T. Ley & Co., of Springfield, Mass., for the camp at Ayer, Mass.; Irwin & Leighton, of Philadelphia, Pa., for the camp at Wrightstown, N. J.; Hardaway Construction Co. of Columbus, Ga., for the camp at Columbus, S. C.; Arthur Tufts of Atlanta, Ga., for the camp at Atlanta; the Hurley-Mason Co. of Tacoma, Wash., for the camp at American Lake, Wash.

To give an idea of the size and character of this work, the Wrightstown, N. J., cantonment contract will serve. This contract is for about $5,000,000, and will provide a city to accommodate 30,000 troops and 15,000 animals. The buildings will be of wood on concrete foundations. A sewer and water system will be provided, also roads and railway facilities, on a 4,000-acre tract of land.

Since cantonments for at least 600,000 men will be built before fall, it would appear that nearly $100,000,000 may be expended for this work, if the cost of the Wrightstown cantonment can be taken as a criterion.

There are to be at least 16 cantonments—possibly more—and the general contractors are to receive 6 per cent on the cost as their fee, which is to include their managerial and office expenses but not the furnishing of construction equipment and tools. Tools are to be purchased by the government and construction equipment will be rented from the contractors.

Sub-contractors are requested to apply direct to the general contractors for work. Considering the magnitude of this work and the speed with which it is to be done, it seems likely that many a sub-contractor will secure work for the summer. Also it is probable that after the present plans for cantonments have been placed under contract, it will be found advisable to extend the work and to provide additional training camp accommodations.

SAND AND GRAVEL PLANTS OWNED BY THE CALIFORNIA HIGHWAY COMMISSION.

In building the great highway system of California—for which another $15,000,000 is now available—the State Highway Commission has frequently found it economic to open up and operate sand and gravel pits. Thus, near San Luis Obispo, sand is obtained from the bed of the Salinas River, at a cost of 25 ct. a ton.

This plant consists of a cableway 700 ft. long on which travels a ¾-yd. drag-line bucket. A 40-HP. boiler operates the engines that haul the bucket and revolve the screens. The sand is delivered into bunkers alongside a railway spur. Although the output of this $7,000 plant was only about 25,000 tons during the first year after installation, the cost was less than 25 ct. a ton.

For many years the Los Angeles County Highway Commission has profitably operated a quarry and crushing plant near Los Angeles. In this case, as in the case of the California Highway Commission, the successful operation of these plants is largely attributable to their being under the control of competent engineers and free from the ordinary political machinations that so often characterize the operation of publicly owner plants.

CONTRACTS AWARDED TO ENGINEERING FIRMS FOR WOODEN SHIPS.

Although it has been said by Gen. Goethals himself that steel ships will be given the preference, it is already evident that he intends to build a large tonnage of wooden ships.

Terry & Tench, the well-known engineering contractors of New York City, have a $10,000,000 ship building contract at Savannah, Ga.

Sanderson & Porter, equally prominent in the engineering world and also of New York City, have a contract for ten modern ships. Their works are at Willata Harbor.

Maryland Shipbuilding Co. of Baltimore, have a contract for six wooden ships.

Altogether 12 contracts have been let for 104 ships and hulls to be built under Gen. Goethals' direction, and of these 54 ships and hulls are to be of wood.

Of the three billion dollars just appropriated by Congress $750,000,000 is to be expended in shipbuilding. Of this huge sum a very substantial part will be used to build modern ships, contracts for which will, for the most part, be awarded to engineering contractors. At present Gen. Goethals favors unit-price contracts for ship building, but it seems to us likely that some form of cost plus a fee contract may be adopted for part of the work.

$10,000,000 A YEAR FOR FEDERAL LEVEE WORK.

During the next five years the federal government will spend $50,000,000 on levee work along the Mississippi, as provided for in a bill passed by the last Congress. This will involve handling 175,000,000 cu. yd. of earth and the protection of banks, where scouring would occur. The work will be done under the direction of the U. S. Army engineers, and the headquarters of the Mississippi River Commission will be at St. Louis.

Now that there is assurance of continued levee construction on a large scale, we look to see excavating machinery used on a scale not hitherto regarded as economic for levee work—on the Mississippi. Drag-line scrapers, shovels and cars are likely to displace many mule team outfits. There remains, it is true, the problem of consolidating the embankments mechanically, but, as the inventor of the "rolling tamper" said: "When I realized that I couldn't afford to hire a flock of sheep to compact the dirt, I decided to invent a flock of sheep." And he did, simply by putting projecting spikes all over the periphery of a roller.

We suggest that "rolling tampers" of this type may be pulled in trains by tractors or by drag-line cables, after mechanically spreading the earth in the levees. A "rolling tamper" is not only more efficient than a smooth or a grooved roller, but it does not clog up when the earth is muddy. In addition, it is its own inspector; for when the "sheep's feet" of the roller walk on the top of the earth—and not till then—the earth is completely compacted.

THE "EXCAVATING ENGINEER" SUSPENDED DURING THE WAR.

We are sorry to receive announcement of the discontinuance of "The Excavating Engineer" during the remainder of the war. Its editor and manager, Mr. Bradlee Van Brunt, is a member of the Wisconsin cavalry which has been called into service.

Mr. Van Brunt has produced an interesting and useful monthly magazine, and we trust that it will not be many months before he again resumes his editorial work.

EDITORIAL COMMENT.

During this year automobiles totaling more than 25,000,000 H.P. will be built. This equals the power of all the horses and mules in the country. Truly the giant gasoline horse is making the hay horse look like a pygmy.

Forty-five million tons will be the steel crop of America this year, according to Schwab, or a gain of 10 per cent over last year's record-breaker. In 1880 the output was only 1,000,000 tons. The increase in tonnage of 1917 over 1916 will alone build all the steel ships that

Gen. Goethals plans to turn out during the next 18 months. Yet there are those who have spoken of the inability of our steel mills to carry this additional burden of new ships.

On the payroll of the Bethlehem Steel Co. are 75,000 men whose wages last year averaged $1,200 per man. A 10 per cent increase in wages has occurred since the first of this year. At this rate it will not be long before Schwab will make Ford look to his crown as the prince of high wage advocates.

It is said that the foodstuff daily found in the garbage cans of Chicago averages half a pound per capita. Since the actual consumption of food is about 3 lb. per capita, it appears that fully 16 per cent is wasted in this city. Add to this the waste that occurs in the markets, and it is apparent that the waste of foods is not far from 20 per cent. Evidently a good place to start an economy campaign is in the kitchen and at the dining table.

The Pennsylvania Railroad plans to replace many men with women for clerical work. Probably women will also be used to a considerable extent in telegraphy, signalling, train dispatching, ticket selling, etc. The men relieved from these duties will be used on other railway work when they are not required for military service. It seems probable that the scarcity of workmen in many industries will be speedily remedied by more extensive employment of women.

A census of gasoline and kerosene farm tractors shows that there are about 34,000 in America at present. This is scarcely "a starter." There is need of millions of tractors, and fortunately some of the great manufacturers are planning to supply the want in the next few years.

Few contractors or engineers seem to know the most efficient method of boiling food for large numbers of men. The editor first learned the best method from a donkey-engineman who had undertaken to feed a large crowd at a "camp meeting." He cooked "New England boiled dinners" for about 200 people each day, and did it without a cook stove. The vegetables and meat were put in bags and submerged in water in a row of beer barrels. Steam pipes into the barrels from the boiler of a "donkey" did the rest. Live steam from the open ends of the pipes brought the water to a boil in a few minutes.

COMPARATIVE SMALL PROFITS OF THE RAILWAYS.

To the Editor: The brief editorial under the caption, "The Comparative Small Profits of the Railways," in the May 23d issue of Engineering and Contracting merits both attention and commendation.

The import opens up a very broad question with many phases. It is true that for some years the public treatment of our railways and other utilities has not been constructive in results. The trying time of war now will seek to illumine this in more ways than one in a weakened efficiency for the properties existing and a lack of transportation facilities where needed.

Artificial and sophistical economic theories have greatly influenced the regulation of these businesses and now to rectify under stress makes the problem the more acute. But to change now, policies must be turned about and into practical channels and by fair means. Encouragement must be made for investment in such property on a basis equal to that for others, if private ownership is to obtain. The matter of ownership, too, should be placed so that no shadows overcast needed enterprise.

As was so aptly stated in the item referenced, quibbling should be put away, especially when we are thinking of billions in capital. Engineers are greatly influenced by those things relating to our railways. Perhaps those in this avocation should take a more active part in formulating constructive policies for these properties. It seems vital that they should.

Lincoln, Neb. E. C. Hurd, Consulting Engineer.

GAIN IN STRENGTH OF CONCRETE DUE TO WASHING AND GRADING OF AGGREGATE.

To the Editor: Enclosed find the results of tests on concrete cylinders made from local cement and local sand and gravel aggregates. The first set marked No. 1 was made from concrete taken from the mixer during the construction of a Pierce county paving job. The sets marked Nos. 2, 3, etc., were hand mixed and moulded at the plant of the Tacoma Sand & Gravel Co. and are from similar aggregates and cement. The specimens were broken at the age of 30 days at the Structural Materials Laboratory of the University of Washington:

Mix	Cylinders. Lbs.	Equivalent Cubes. Lbs.	Remarks.
No. 1—			
1:2:3½	5170	6080	
	4570	5370	Ungraded gravel 2 in. to ¼ in. of which 11.5 per cent passed the ¼-in. mesh.
	4630	5440	
	5060	5950	
Average	4875	5730	
No. 2—			
1:2:3	2900	3410	
	3140	3700	
	3330	3920	Ungraded and unwashed gravel and sand.
	3270	3850	
Average	3160	3720	
No. 3—			
1:2:3	3260	3760	
	3940	4640	Ungraded washed gravel and sand.
	3530	4150	
	3760	4200	Shows gain of 12.5 per cent for washed material.
Average	3610	4200	
No. 4—			
1:3:6	2220	2570	
	2280	2680	
	2370	2800	Ungraded gravel and sand.
	2240	2580	
Average	2280	2660	
No. 5—			
1:3:6	2800	3300	
	2940	3460	Graded gravel and sand on three sieve separations.
	2880	3390	
	2870	3380	Shows gain of 20 per cent due to grading.
Average	2875	3380	
No. 6—			
1:1½:3	4400	5170	
	4470	5260	
	4640	5460	Ungraded gravel 1½ in. to ¼ in.
	4880	5750	
Average	4600	5410	
No. 7—			
1:2	3670	4320	
	3600	4240	
	3730	4380	Ungraded gravel 1½ in. to ¼ in.
	4100	4820	
Average	3775	4440	
No. 8—			
1:2½:5	3400	4000	
	3440	4070	
	3320	3910	Ungraded gravel 2 in. to ¼ in.
	3440	4050	
Average	3400	4000	

The specimens were cured in damp sand 25 days and broken at the age of 30 days. They contained .06 per cent water for the 1:3:6 mix to .08¼ per cent for the 1:1½:3 mix.

Tacoma, Wash. Russell J. Borhek, C. E.

Utilization of Quarry Strippings.—Serviceable sandstone deposits are usually overlaid with sand, gravel, clay and thin bedded waste sandstone. In removing this waste material the overburden, in some instances, is of such a nature that it may be utilized for the manufacture of by-products, and the net expense for stripping may be greatly reduced, or the overburden may even be removed at a profit. Certain quarries near Pittsburgh utilize a clay or shale overburden for the manufacture of brick and tile, and a sandstone quarry near Cleveland contemplates the establishment of a vitrified-brick plant to utilize shale stripping. In other localities the products of stripping are utilized to advantage in improving quarry property by filling in depressions around quarries or shops, or in grading roads and railroads. At Berea, O., abandoned excavations are filled to the original level, and are used for building lots. Areas from which all the serviceable stone has been removed are thus rendered productive and bring an income to the quarry company.

UTILIZING "OVERSIZE" TO INCREASE OUTPUT OF SMALL GRAVEL PLANTS.

Small stone crushers are playing an important part in increasing the output of the smaller gravel plants of this country.

In many cases the installation of a crusher has been an afterthought on the part of the plant owner. It was not in his original plans, but when he found that 5 to 10 per cent of his gross daily output was oversize gravel the wisdom of putting in equipment to utilize this rejected material was apparent. A pile of "oversize" at an Illinois gravel plant is shown in Fig. 1. This photograph was taken in 1915 and since then this producer has installed a crusher and all the gravel that comes out of his pit reaches the market.

Just because the rejected material does not accumulate fast enough to keep a crusher busy continually is no reason why the installation of a crusher should be deemed unprofitable. Consider the case of a certain small plant in Indiana which is typical of others that are allowing their oversize gravel to go to waste. The material at this plant is excavated from a river with a dragline cableway excavator which digs and conveys to the screens about 150 yd. a day. Of this gross amount about 10 yd. a day is rejected by the first gravity screen and of the remaining 140 yd. about one-half is very fine sand for which there is no market. Thus, the net daily production of graded gravel and sand runs about 70 yd. Ten yards of crushed gravel could be added to this output by installing a small crusher and bin with a capacity of 10 yd or so. The bin would hold a day's accumulation of "oversize" and an hour's run of the crusher would reduce all this material to commercial sizes. This plant has had a ready market for more gravel than it can supply, so it would appear as if a crushing outfit would be a wise investment.

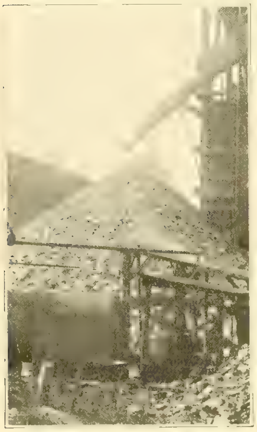


Fig. 1—"Over-size" Material at Illinois Gravel Plant.

There are plants, of course, where the percentage of oversize is not enough to warrant an expenditure for crushing equipment; but even in such plants the character of the material encountered is liable to change at any time and if the gravel becomes more coarse as the pit goes deeper a little calculating may disclose that a crusher will pay good returns on the investment.

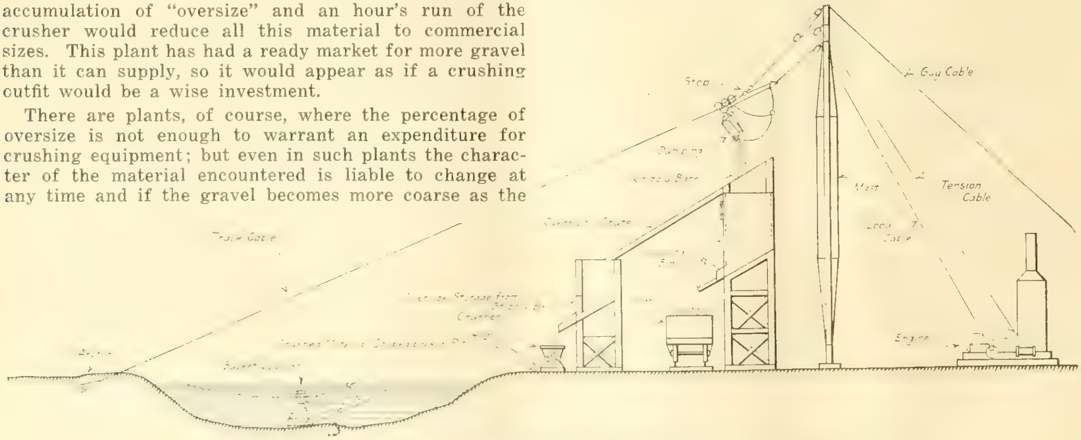


Fig. 2—Crusher Installation That Increased Marketable Gravel Output 10 to 20 Per Cent.

Such a condition has arisen at an Indiana contractor's gravel plant which has been in operation only a short time. He is digging gravel with a 1-yd. Sauerman dragline cableway excavator. There was only a small percentage of boulders encountered at first, but now the daily gross output of 300 yd. is running heavier and heavier to coarse material. An installation of crushing machinery that meets the requirements of this plant is shown in Fig. 2. The "oversize," which formerly tumbled down a wooden chute to a pile at one end of the plant structure will now pass down a somewhat longer wooden chute to a small wooden storage bin built with a gate or hopper bottom to feed into a crusher of about 20 tons an hour capacity, driven by a 20-HP. motor. This is located at the edge of the pit and a little to one side of the line of travel of the cableway bucket.

From the crusher a conveyor about 15 ft. long extends out over the pit and feeds the crushed gravel onto a chute which drops the material in the path of the excavator bucket to be elevated and fed to the screens. Bin, crusher and conveyor are mounted on skids for moving to conform with the frequent changes in the line of operation of the cableway bucket. Thirty minutes run of the crusher several times a day will crush all the "oversize" material, giving this contractor 20 or 30 yd. more of commercial gravel every day, and there is a market for every yard he can produce.

A similar method of reclaiming the "oversize" is in use at the plant of the Indiana Gravel Co., Inc., Indianapolis, Ind., shown in Figs. 3 and 4.

The crusher is a No. 9 Telsmith jaw crusher which has a capacity of about 8 to 10 tons per hour with a $1\frac{1}{2}$-in. crusher opening. The power is furnished by a 25-HP., 3-phase, 60-cycle, 220-volt, 1,200-r.p.m. A. C. motor. Crushing from 30 to 45 cu. yd. of oversize material per day, the average daily cost for current is about $2.50, according to Mr. Jesse A. Shearer, president of the operating company.

The oversize material rolls off the grizzly bars into a chute which conveys the material into a hopper elevated above the crusher and about 10 ft. to one side. This receiving hopper holds about 12 yd. of material and the crusher is operated only when the hopper is full. About 30 to 45 minutes is required to empty the hopper, and it is only necessary to operate the crusher three and four times during a day's run of 10 hours.

There is a trough, or chute, leading from the receiving hopper over to the crusher, which has a fall of about 3 ft. in 10. By the aid of a hopper gate the operator can control the feed from the receiving hopper into the trough and the gradual incline of the trough leading from the receiving hopper to the crusher gives the operator an opportunity to sort the material by hand and to throw out any objectionable material before the oversize reaches the crusher. The gravel is dredged out of a flowing stream and occasionally pieces of wood and other foreign matter are encountered which the operator sorts out by hand.

The crushed material is carried from beneath the crusher by a Link Belt bucket conveyor. This conveyor sets at an angle of about 60° and is operated by sprocket chains leading from the main shaft on the crusher. The

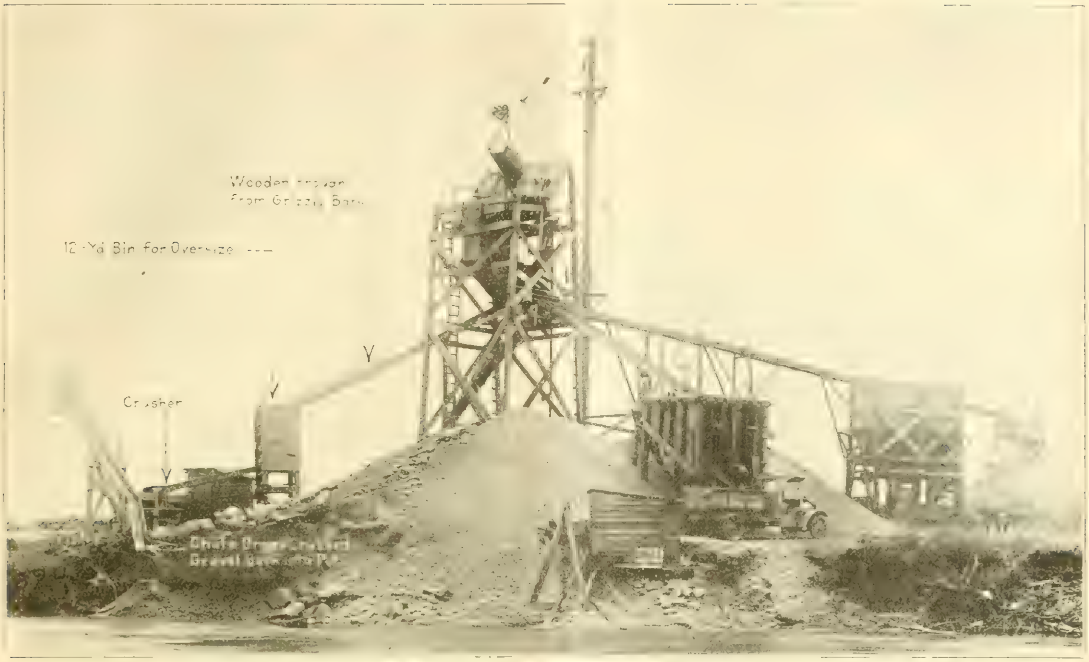


Fig. 3—Crushed Gravel Is Dropped Back Into Pit and Carried Up to Screens by Cableway Excavator.

conveyor deposits the crushed material into an incline trough about 20 ft. above the ground, through which trough the material rolls by gravity back in the river, immediately into the path of the drag line excavator. During the course of a day's run the operator of the drag line can drop his bucket down near the bank and pick up the crushed material at his will and deposit it into the receiving hopper above the gravity washing and screening plant. In this manner the crushed material passes over the screens and is mixed with the screened gravel, making a clean, sharp concrete aggregate.

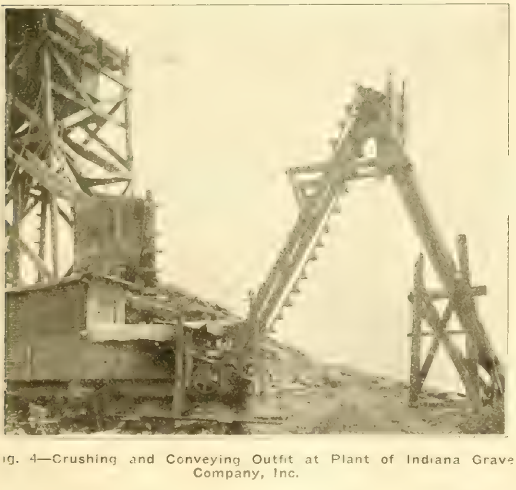


Fig. 4—Crushing and Conveying Outfit at Plant of Indiana Gravel Company, Inc.

An economical feature of this installation is the fact that the operator is able to handle the crushed material with his Sauerman drag line cableway excavator and dispenses with an extra conveyor for returning the crushed material to the receiving hopper.

In one of several small gravel plants operated by the Nickel Plate Gravel Co., Erie, Pa., the oversize material is crushed by a No. 3 Telsmith primary breaker. The crusher is driven by a belt from the engine which operates the other plant machinery and is equipped with a clutch pulley so that it is necessary to turn it over only when it is actually working. The "oversize" runs from 6-in. to 2-in. in size and is reduced to 1¾-in. An 8-yd. hopper is built over the crusher and the material rejected at the "grizzly" is chuted into the hopper. When the hopper is full, 30 minutes' run of the crusher will empty it and three or fours runs of the crusher a day will take care of all the "oversize."

A larger plant is shown in Fig 5. This plant was erected by Raymond W. Dull at Chillicothe, Ill., for the Mackinaw Sand & Gravel Co. In this plant the storage bin for "oversize" is part of the main timber structure and has capacity for about 80 yd. of material. The illustration shows how the crusher is fed by a spout from the storage bin and how the crushed material is then elevated by an enclosed bucket elevator to the washing screens. The crusher is a No. 5 Austin gyratory crusher capable of crushing 12-in. rock and boulders down to 1½-in. size. Its capacity is 30 tons an hour, and as this far exceeds the amount of "oversize" which will accumulate in an hour, the crusher is only operated intermittently. It is equipped with clutch pulley and operated by rope drive from the engine which also drives the pump, screens and elevator.

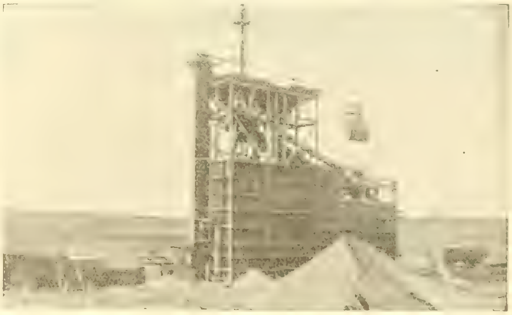


Fig. 5—Plant of Mackinaw Sand & Gravel Co., Chillicothe, Ill.

For intermediate or secondary crushing, disc crushers or large crushing rolls are quite frequently used in the large capacity gravel plants, and where there is a large amount of "oversize" not over 6 in. in size, they can also be profitably employed as primary crushers. In dredging from a river with a centrifugal pump outfit, the Northern Gravel Co., Muscatine, Ia. (see Fig. 6), obtains gravel containing a large amount of over-size" which is all between 1¾ and 3 in. in size. In this plant, designed by Raymond W. Dull, a Symons "36" disc crusher reduces the "oversize" to 1-in. size. This is an excellent installation under the circumstances, but it would not be economincal for a small capacity plant.

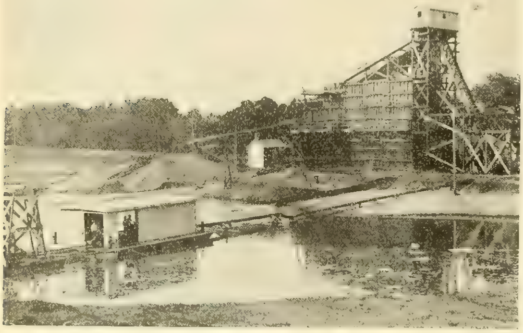


Fig. 6—Plant of Northern Gravel Co., Muscatine, Ia.

LOCATION OF MAGAZINES FOR STORAGE OF EXPLOSIVES.

Magazines for storage of explosives should be weather-proof, fire-proof, thief-proof, and bullet-proof. Moreover, they should be located at a safe distance from other buildings, and from railways and public highways. The only rational way to determine what is a "safe distance" in any given case is to study the accidents of the past, and find out the limiting distance at which damage was actually done by the detonation of known quantities of explosives. Several studies of this kind have been made, and tables of "safe distances" have been prepared in accordance with the results obtained. One of these tables (put out by the Bureau of Mines) is printed in the June Travelers' Standard in somewhat abridged form as follows:

MINIMUM PERMISSIBLE DISTANCES BETWEEN BARRICADED MAGAZINES AND PUBLIC HIGHWAYS OR INHABITED BUILDINGS.

	Minimum Permissible Distance (in feet) from	
Pounds of explosive stored	Public Highways	Inhabited Buildings.
50	70	120
200	155	260
500	240	400
1,000	320	530
5,000	470	780
10,000	535	890
30,000	725	1,205
100,000	1,100	1,835

Device for Removing Water from Drill Holes.—A simple device for removing water from drill holes is employed at some of the sandstone quarries in Ohio. It consists of a piece of gas pipe 5 to 7 ft. long, with a nut or other piece of metal having a round hole, fastened in the lower end of the pipe, the connection being as nearly water-tight as possible. A marble or a round steel ball is placed above the nut, and about 6 in. above it a bar is placed across the pipe to prevent the ball from falling out. When the pipe is dropped into a drill hole water enters through the lower hole, and the ball fitting into the hole acts as a valve and prevents the water from running out while the pipe is being removed.

LABOR CONDITIONS IN THE HAWAIIAN ISLANDS.

Contributed by James E. Foss, Jr.

Labor in any locality is a problem, but the question seems to have many phases of its own on the Hawaiian Islands where we have a mixture of Oriental and Occidental races to deal with. It will appear peculiar, and perhaps we hate to admit it, but the Oriental labor in the islands is the most stable and is the standard on which the employer figures. In saying Oriental one might say Japanese for they predominate. If a contractor is asked what a certain piece of work will cost he invariably will answer "say $10,000," if Japanese non-citizen labor is used and "$15,000" if citizen labor is used. So, therefore, we have the Oriental and the Occidental labor under different names, non-citizen and citizen labor.

The Jap is the standard, but we have along with him the Korean and a few Chinese. These men are all easily handled and managed on a construction job. They are worked under contract which in this case is no more than an agreement to do a small piece of the job for a certain sum without bonds. The only assurance the employer has in the way of a bond is that a percentage is held back each month until the work is completed. If the Japanese are held in proper control they will under this scheme work hard, take care of themselves in the way of provisions, camp, etc., and do a satisfactory job; if they were put on the job by the day they would likely be useless.

This way of handling Oriental labor is used altogether by the sugar and pineapple plantations. The usual plan is to give a flat rate for the work and a bonus for efficiency. Thus, for example, in the care of sugar cane planting, say, 20 men are given a contract as a company to cultivate a field. They are guaranteed a certain flat rate and bonus on every ton of sugar for that field over a certain stated tonnage. Thus one finds that an effort is made to produce the maximum amount of sugar on that field. Every drop of irrigating water is put to the best advantage, not a weed can be found even in the paths between sections, and in fact absolutely nothing is wasted nor is anything allowed to hinder one plant from growing in as far as the laborers can help. Of course this is the ideal. Often there is dissention among men themselves in a company, for lazy men will get in; but as far as the plantation is concerned, unless this trouble is very serious and the majority of the company is no good the other laborers themselves will throw out the drones. So much for the Oriental labor and how it is handled efficiently.

The Occidental or citizen labor which comprises the native Hawaiian, the Portuguese, Spanish, Russian and Porto Rican often work efficiently under the same scheme as the Japanese. As a rule, however, they are of the day labor class. The Hawaiian is not much in favor of plantation work, for he wants something that is not quite so monotonous and with less routine. He also wants a job where a day missed once in a while will not be chalked up against him. He must have time for his play and it might be said that in his case where pleasure interferes with work, he quits work.

The Portuguese are not scared of work—hard work—but they are thrifty and are not going to work for an employer any longer than it takes them to gather enough money to buy a piece of land and cultivate it themselves. They are good citizens, very proud of their adopted country and are year by year becoming the main stay of the islands.

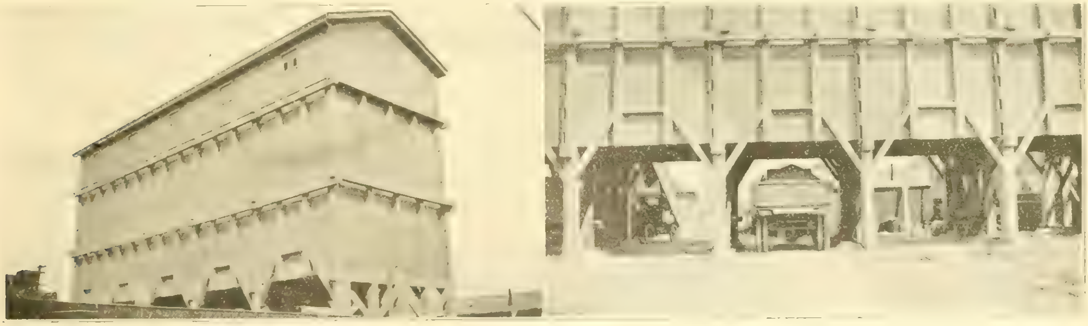
The Spanish that have come to the islands as laborers are a degenerate class, although a very few of them do as good work as their neighbors, the Portuguese. They have a lot to realize before they will become efficient as laborers.

The Russian is a good, hard worker, but he seems to be unable to handle himself in a free country. He will drink heavily and thus impair his efficiency. He has not been in the islands long enough for one to see what the second generation will be, but so far prospects are good.

The imported Porto Rican is a "happy-go-lucky" fellow who when he first came to the islands and for several years afterward could not be strictly law abiding no matter how much he tried. Work does not scare him, but he does not know the first rudiments of sanitation or how to give his health a fair chance. He loves to fight, drink and use the knife, but usually among his fellow countrymen. He will take a contract on the plantations the same as the Japanese and do very well, but he must be allowed to do it his own way.

But don't forget the Filipino, who is in a class of his own, and with, of course, exceptions has all of the bad, listless quantities of every other class of labor, combined with a great hankering for outward show. In disposition he does not realize that a man is what he makes himself. His idea is that by inheritance he is as good as any man and no foundation is needed. He has surpassed the Porto Rican many times in giving trouble in the criminal courts. As a laborer the Filipino is a failure. He does not know how to work, even if he might have the incentive. Often he is physically weak and has not strength even to do the lighter jobs. His diseased system and mode of living does not give much hope of him becoming much of an asset to the laboring class. Still, at present he is used by the pineapple canneries where intermittent labor is required on monotonous work; he is also becoming a favorite as a house servant when his health and stealing instincts admit of his employment.

A skilled mechanic has no chance here, although he certainly is needed. The laboring races are not capable as a rule of being trained into skilled labor, but are pushed into it and the employer has to put up with the results. The present day trouble is that the skilled mechanic who is a good man at his trade does not come to the islands, where the field is small, but the mechanic who is a failure somewhere else does come and other than his ability to growl about the use of Oriental labor he is not a success. Thus the employer is forced to employ the local mechanic, although he would much rather have a good, efficient man from the mainland.



Retail Crushed Stone and Sand Unloading and Storage Plant of Chicago & Oak Park Supply Co.

The following present day wage scale is given for what it is worth, but the reader must not forget the fact that in comparing this wage scale with that of other places, the comparison of what a man can accomplish in a day is very much smaller in the Hawaiian Islands than elsewhere. This is due to the climate, which produces a general dilatory effect on the laborer.

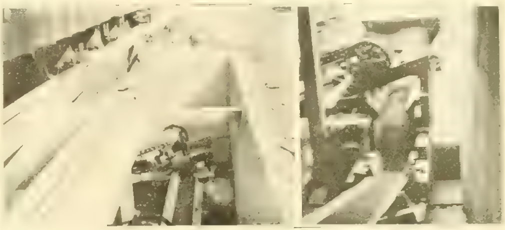
WAGE SCALE IN HAWAIIAN ISLANDS

	Races					
Class of work	Japanese	Hawaiian.	Portuguese	Russian.	Porto Rican.	Filipino.
Pick and shovel...	$1.75	$2.00	$2.25	$2.25	$1.75	$1.25
Teamsters	1.75	2.25	2.25		....	....
Concrete finishers.	3.00	2.75		4.50	....	.....
Carpenters	2.75	3.00	3.50	4.00	3.00	2.00
Quarry men	[illegible]	2.00	2.50	2.00	2.00	1.25
Tunnel men	3.50	....		....	3.00	...

MODERN RETAIL MATERIAL HANDLING PLANT.

For reducing labor and increasing motor truck efficiency, the plant of the Chicago & Oak Park Supply Co. at Oak Park, Ill., is a typical example of a modern material-handling plant of a design that could be successfully applied to almost any retail material yard.

The company operates a fleet of Pierce-Arrow motor trucks and every possibility of wasting time in loading these trucks is eliminated by this overhead storage. Only 10 seconds are required to load the largest truck at this type of plant.



Receiving Hopper and Elevating Machinery.

The principal machinery contained in the plant consists of three endless steel apron conveyors located directly under the receiving track hopper where the railroad cars dump. From these steel apron conveyors the material is discharged into a gathering apron conveyor which delivers the material to the foot of the inclined 18-in. belt conveyor which raises the material up over the storage bins.

Another belt conveyor, with a traveling tripper is located on top of these storage bins. This tripper may be set over any desired compartment under its own power by merely moving a lever.

The building is divided into five bins of a total capacity of about 800 cu. yd. which are used for storing three sizes of crushed stone, torpedo sand and bank sand. The bins have a flat bottom allowing additional storage which comes in quite useful when there is a shortage of material. The material which is in "dead" storage may be recovered by shoveling into the openings in case of an emergency. This flat bottom also permits the wear to fall on the material which is not the case when bins are built with inclined bottoms.

The material is withdrawn from the storage bins through duplex clamshell gates which are set flush with the bottom of the bin. These gates require very little effort in opening and closing.

A car-puller located at the receiving track hopper pulls the cars down to the hopper to be dumped. The plant has an elevating capacity of about 15 carloads per day. All conveyors are driven by individual electric motors which minimize the expense of power for operating.

This plant was designed by James B. Seaverns, engineer and contractor, People's Gas Bldg., Chicago.

LOCOMOTIVE CRANES ON RAILWAY MAINTENANCE AND CONSTRUCTION.

Locomotive cranes are being used extensively by the Elgin, Joliet & Eastern Ry. on maintenance of way work and construction operations. The crane has proved to be effective and economical in handling not only small jobs of concrete work but also jobs of considerable proportions. It has been found especially useful for the quick handling of materials where it is necessary that there be no delay of traffic. The Elgin, Joliet & Eastern Ry. also has found the cranes very effective in the present car situation for unloading and reloading cars at terminals in order that the equipment may remain in revenue service as much as possible.

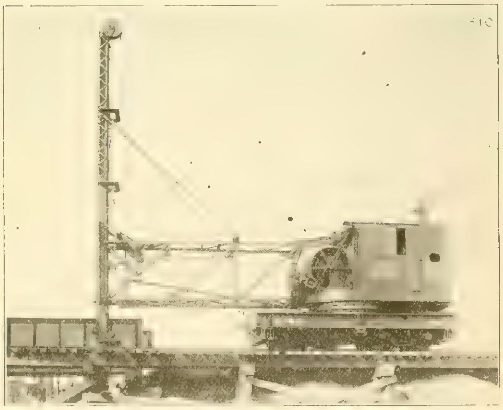
The methods employed by this railway in handling small concrete jobs along the main line are particularly interesting. This work is handled about as follows:

The construction gang moves its outfit to the location at which the work is to be done, places the necessary platforms for unloading gravel and sand, also arranges the necessary cribbing for setting up the concrete mixer. The foreman advises the Bridge and Building Department when everything is ready at location of work for receiving material and concrete outfit. The work train, made up about as follows, is then ordered from the terminal:

The locomotive crane, cars containing the necessary sand, gravel and cement to complete the job in view, also any additional supplies that may be required more than those which the foreman has remaining from his last job. The foreman and gang come from the job they are preparing to do on motor car to the location of the job which they have just completed, where they meet work train coming out from the terminal.

All material left from the job previously completed, such as concrete mixer, portable cement house, blocking, form lumber, and any sand and gravel that may be left over, is loaded by the locomotive crane. This usually consumes from two to three hours. This train then moves to the location of new job where the cement house, concrete mixer, sand and gravel are unloaded on platforms and cribbing previously set up by the bridge gang.

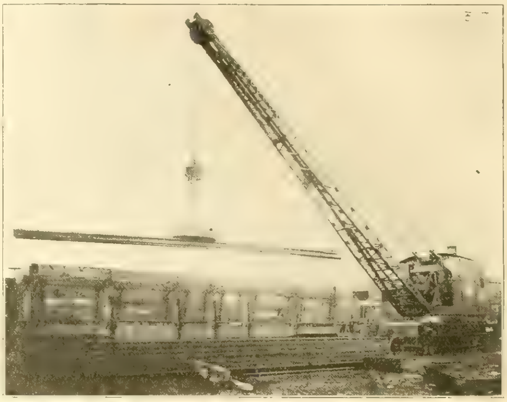
This can all be done between trains and with scarcely any delay to traffic. Also, as a rule, it can be done with one day's work train service. In cases where falsework is required, it is necessary to send out the work train a few days in advance, with the locomotive crane rigged up with pile driver attachments for the purpose of driving the necessary piling. As a rule piling for any ordinary structure can be driven in one day, the work train then returning to the terminal with the crane.



Orton & Steinbrenner Locomotive Crane with Pile Driver Attachment Used by E., J. & E. Ry.

The foreman then digs out under tracks, caps the piling and prepares everything for stringers and bridge ties. When he has everything in readiness he notifies the office and the work train is ordered about as outlined above except that the necessary stringers and bridge ties are included in the outfit.

When the work train arrives on the job, the unloading of materials is proceeded with until such time as the foreman receives advice from the dispatcher that the track can be abandoned for a couple of hours. When this class of work is done, sectionmen are lined up beforehand and on the job. The track is then taken up and stringers and bridge ties set in place. If everything goes well this can generally be accomplished in one day and also a large part of the embankment or excavation removed by the bucket attachment to locomotive crane. By handling work in this manner the Bridge and Building Department has found that it not only makes a saving of time but it also can arrange the work so that traffic is very seldom delayed.



Orton & Steinbrenner Locomotive Crane With Lifting Magnet.

Wm. B. Hotson is Superintendent Bridges and Buildings and A. Montzheimer is Chief Engineer, Elgin, Joliet & Eastern Ry.

AMMONIA EXPLOSIVES IN UNDER-WATER WORK.

Comparative tests of ammonia dynamite and straight dynamite in removing snags from streams were conducted recently in the Vicksburg District of the Mississippi River Commission. The tests were made with 40 per cent low freezing ammonia and nitroglycerin dynamite. Electric blasting caps were used as detonators. The band of dynamite was fastened around the base of the stump under the water. In the first test the dynamite was left under water for 22 minutes and when exploded with the blasting machine a perfect explosion was secured, blowing the stump to pieces. Both the straight and ammonia dynamite were tried under water and as good execution was secured with one as with the other. Ammonia explosives contain a little less than half as much glycerin as the straight grades and consequently are sold at a considerably lower price per pound.

Utilization of Waste from Sandstone Quarries.—In many cases the heavy, irregular blocks of sandstone from quarries are used for shore protection purposes. For certain uses riprap of a smaller size than many of the original waste blocks is required. Mud-capping or block-hole blasting is commonly employed to break the larger masses. A ball breaker is used for this purpose by one Kentucky company. A heavy iron ball is hoisted with a derrick, is centered over a block, and tripped. The impact of the ball breaks the block into fragments. The cost of power involved is much less than the cost of drilling or of explosives employed for the ordinary method, and the process is said to be more effective.

OVERHAUL IN IRRIGATION CANAL CONSTRUCTION.

Contributed by Charles W. Helmick.

Practically all excavation in engineering construction is paid for by the cubic yard, which in most cases applies to excavation only. Rarely are both excavation and embankment paid for, and there are generally clauses in the specifications limiting the length of free haul, and the contractor is paid a specified amount per cubic yard for each 100 ft. overhaul, designated as cu. yd. sta.

In railroad work this is readily ascertained, as the pivot point is the section where the cut ends and the embankment begins, and an inspection of the calculated volumes and the profile will show the stations between which the free haul limit applies.

As it is impossible to trace each cubic yard of excavation to its place in the embankment, the clause in the specifications governing overhaul should be specific and provide that in calculations for overhaul the distance from the pivot point to the center of gravity of each prismoid of excavation should be calculated; likewise the distance from the same to each prismoid of embankment in which the excavated material is placed, making due allowance for the estimated shrinkage. From these data the distance to the center of gravity of the section in excavation and to the center of gravity in embankment from the pivot point can be calculated, the sum of which, less the free haul specified, will give the average overhaul and the cu. yd. sta. to be paid for can readily be calculated. In determining the center of gravity of a prismoid the distance from an end section to this can readily be found as follows, using average end areas in the calculations:

Let $A =$ one end area,
$B =$ the other end area,
$l =$ length of prismoid,
$x =$ distance from mean section to end area A.

$$\text{Then } \frac{1}{2}x \left(\frac{A+B}{2} + A \right) = \frac{l - x}{2} \left(\frac{A+B}{2} + B \right)$$

$$\text{Whence } x = \frac{l}{4} \left(\frac{A + 3B}{A + B} \right) \text{ which is easily applied.}$$

Then, knowing the distance from Section A from the pivot point, the lever arm of each prismoid is found by addition; and the summation of each prismoid of excavation, multiplied by the distance of its center of gravity from the pivot point, divided by the number of cubic yards, will give the average haul in excavation from the pivot point. Calculate the distance of the center of gravity of the embankment in the same manner, and the sum will be the total haul from the center of gravity of the prismoid of excavation.' This diminished by the length of free haul specified gives the average length of overhaul from which the cu. yd. sta. can be calculated.

The case for canal construction is more complicated, and the overhaul cannot be so nearly exactly calculated, inasmuch as irrigation canals are so laid out that a part of the carrying capacity section is usually in embankment which is made from the spoils of excavation.

The free-haul limit is also generally much less as the contractor makes the fills adjacent to the cuts from the material excavated with as short a haul as possible, and the overhaul, if any, will apply to the excess material only.

Also, the cubic yards excavation in ordinary earth will not, when placed in fill, make an equivalent number of cubic yards, but there will be a shrinkage of —(a per cent).

Therefore, if we take (100 — a) per cent of the volume of each station of excavation and subtract therefrom the cubic yards of embankment between the same stations, the difference will give the amount of material subject to overhaul, and where this becomes zero it will give the pivot point and where negative, the quantities in embankment, which will have to be made, and an inspection of the differences will show the stations between which the excess excavation will make the fills.

For the purpose of calculating overhaul, the center of gravity of excess excavation for each station may be taken as the center of the station which will give its distance from the pivot point previously ascertained. The same will be true for the volumes in embankment.

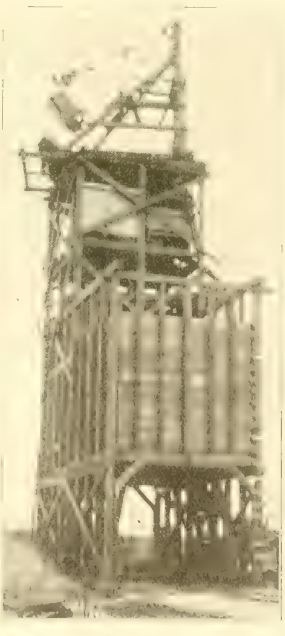
The distance from the pivot point to the centers of gravity of excavation and embankment can thus be easily ascertained, and the sum diminished by the free-haul distance will give the average haul from which the cu. yd. sta. may be calculated.

The above is not theoretically correct as the center of gravity for each prismoid should be calculated as in railroad excavation, but this is not feasible unless the contractor would be required to first make the excavation for the adjacent embankment to the excavation, and then recrossection the remainder which would make the work more expensive to the client and the difference in amount paid for overhaul would not, ordinarily, pay the contractor for his extra work in construction.

For the protection of the client as well as the contractor, the limit of overhaul will generally be specified, as a point may be reached where the cost of overhaul will exceed that of excavation, when borrow will be cheaper if suitable material be found.

CHANGES IN SAND AND GRAVEL PLANT TREBLE OUTPUT.

An example of good results from re-designing and re-equipping a sand and gravel plant is offered by the installation of the Atlas Sand, Gravel & Stone Co. of Hartford, Conn.



Plant of Atlas Sand & Gravel Co., Hartford, Conn.

The original plant had a dragline cableway excavator with ¾-yd. bucket operated by a small one-speed hoist which lacked the power and the change of speed for properly operating the dragline. No effort was made to utilize the oversize, amounting to many yards a day. With this plant, the company could not supply the demand for its product.

The same plant, after being re-equipped with a 600-ft. span 1½-yd. Sauerman dragline cableway excavator operated by a 90-HP. Thomas two-speed electric hoist, adding a crusher for reducing the boulders to commercial sizes, and building on an additional bin, trebled its output. The new plant is shown in the accompanying illustration.

A feature of this plant is that the mast and entire upper structure over the bins is pivoted so that it can be turned in a circle. At the ground end of the track cableway is a bridle hitch. By this arrangement the material within a radius of 600 ft. of the plant can be excavated without moving or re-setting the plant.

Bids are now being asked on a 4,700,000-cu. yd. drainage project in Washington County, Mississippi. The work calls for the excavation of drainage channels for the Black Bayou Drainage District, for which the Morgan Engineering Co., Memphis, Tenn., is the Engineer.

METHODS AND COSTS OF CONSTRUCTING COFFERDAMS AT ST. MARY'S FALLS CANAL.

The construction of the third and fourth ship locks at Sault Ste. Marie, Mich., by the U. S. Government required the building of a cofferdam inclosing an area of 22.51 acres. The cofferdam was commenced in December, 1907, and it was practically completed in the summer of 1909. The total length of new cofferdam construction was 3,150 ft., while 1,074 ft. of existing wall and 671 ft. of old dam brought the total length of water-excluding wall to 5,281 ft. The methods employed in building the cofferdam are described by Mr. W. J. Graves, U. S. Assistant Engineer, in the May-June Professional Memoirs, from which the matter that follows is taken:

The dam was designed and built in nine different sections. These sections were of different types of construction, built by different methods, and at various seasons of the year, as seemed most expedient. Some sections were built by hired labor, some under small contracts and others by a combination of the two methods. One feature common to all sections was the placing of backfilling and crib-filling under minor contracts for "lock pit excavation," let from time to time as the material was needed. Considerable saving in cost was thereby effected, as the material was dumped without cost other than for excavation.

The types of construction varied from a timber crib, rock-filled structure, subject to a direct pressure of 23-ft. head, to land portions of clay puddle wall, only a few feet high, to prevent possible seepage through existing embankment 60 ft. or more in width.

Southeast Dam.—The westerly portion of this section (Fig. 1) is a clay puddle wall 4 ft. thick, built within a sheathed trench excavated by hand to such depth as to uncover the clay of the old Poe lock cofferdam at about elevation 94. As there was some uncertainty as to the quality of the clay in this old dam, as well as its contact with the underlying rock strata, triple-lap oak sheet-piling was driven along both sides of the superimposed puddle wall, down through the clay of the old dam to rock. As the top of slope into the pit came close to this wall, insufficient banking was left and the top of the sheet piling was therefore tied back to the timber canal wall with 1½-in. rods, spaced about 16 ft. apart. This section is 144 ft. long and averaged 20.9 ft. in depth. The work was performed by hired labor at the following cost:

Labor and supplies	$2,676
Materials—oak plank, clay, and iron rods	2,224
Total cost	$4,900

or $34.02 per linear foot, or $1.62 per square foot of wall.

The easterly portion of this section (Fig. 2) is 265 ft. long and consists of 25-ft. lengths of 40-lb. Lackawanna steel piling, driven through a loose rock fill to bed rock. The steel piling extended 4 ft. into the clay puddle wall at either end, thereby making a good tight connection between the two types of dam. For the reason that the slope into the pit came within 10 ft. of the top, this sheathing was also tied back with rods spaced about 20 ft. apart. The work was all performed by hired labor at the following cost:

Labor, supplies, etc.	$1,007
Steel piles and rods	5,358
Total cost	$6,365

or $24.02 per linear foot, or 96 ct. per square foot of wall (salvage not considered).

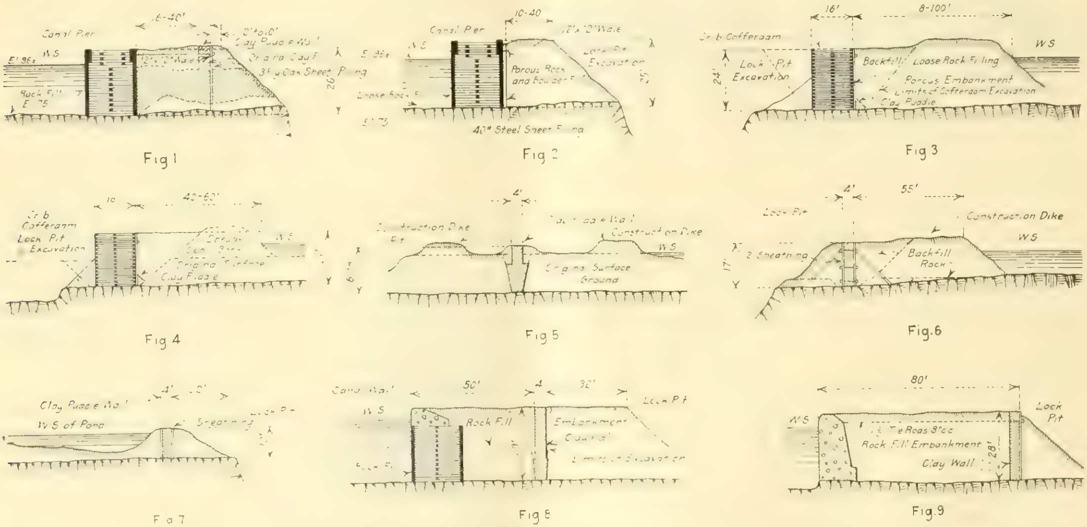
It was known that this piling must be driven through loose rock and boulders. To make sure that its use would be practicable, 10 pieces were purchased first for experimental driving. It is quite possible that its close proximity to the back of a timber crib may have had something to do with the ease of driving. Boulders were frequently struck, but were pushed aside or else the pile twisted slightly, resulting in a curved line around the boulder. Extraction and redriving at a little different angle was necessary in some cases.

In view of the low cost per square foot, practically the same as for the clay puddle wall, the steel piling might have been used advantageously on some of the other sections of dam. It would certainly have saved time, but as practically every other section went through a mass of boulders, large and small, the possibility of driving was problematical.

No credit is given in cost summary for salvage on steel piling, for the reason that it was cut off to top grade and left in place. A local firm contracted to furnish an oxy-acetylene torch outfit and operator at $5 per hour. About 50 ft. of heaviest section was cut at a cost of $1.20 per foot.

North Crib Dam.—(Fig. 4.) This section (Fig. 4) was the first to be built in the wet. But little dredging was necessary to complete a trench 27 ft. wide at the bottom, in which the timber cribs 16 ft. wide were founded. This dredging started at the east end and was carried inland, toward the west, as far as the elevation of bed rock would permit of floating a dipper dredge drawing 9½ ft. of water.

The dredge encountered a boulder 9 ft. x 10 ft. x 12 ft.



Figs. 1-9—Sections of Different Types of Cofferdams Built in Connection With Construction of Ship Locks at Sault Ste. Marie.

in size, which it was necessary to drill and blast, at a cost of $97. The pieces were then removed by chaining to the dipper teeth.

The cribs were 16 ft. wide, 40 ft. long and 21 ft. high. They were built of 8x8-in. hemlock timber. To lessen the cost of construction, on work of such temporary nature, as well as to facilitate their removal later by dredging, they were built corn-cob style, the intersecting timbers being drift-bolted with ½-in. bolts. The ends of the face and back wall timbers projected 6 in. beyond the outside of the end-tie walls, thereby leaving a 12-in. space between the end walls of abutting cribs. Into this space were driven framed locking bents of 12x12-in. timber. This novel scheme worked well, as the cribs were forced into good alignment and held there as firmly as though the cribwork had been built as a continuous structure. The cribs were started on shore, and when about 6 ft. high the 1-in. vertical matched sheathing was nailed onto the side walls and the crib launched, the remaining 15 ft. being added after flotation. Oil barrels were employed as buoyancy pontons during the latter stages of construction and placing. The bottoms of the cribs were built to conform to the uneven rock bottom, as determined by soundings taken 3 ft. apart along the line of the crib walls.

Considerable difficulty was experienced founding cribs on the rock. During the interval of several months which elapsed after dredging, considerable material settled over the bottom in a hard compact layer and, furthermore, the dipper dredge failed to clean the bottom in a satisfactory manner. A derrick boat and diver were employed to pick up the coarser material. The cribs were then floated to place and sunk. A small drag-line scraper, guided by the diver, was first employed in an unsuccessful attempt to seat the cribs. A water jet, with ⅜-in. nozzle, under pressure varying from 60 to 120 lb., was then employed successfully, although the amount of material to be cleared away was so great that an 8-in. centrifugal sand pump, running at 450 r.p.m., was operated to remove the material as fast as loosened by the jet. The 8-in suction pipe was pivoted to permit of dragging along the bottom. The divers, working 4-hour shifts, so manipulated the jet that the material was driven toward the suction, which removed it instantly, allowing the weighted crib to settle into place. Part of this clean-up work was performed during winter months, and the diver's air pump was housed in a heated shed on the crib to permit him to work without discomfort. The removal of ice around the cribs proved an added disadvantage and expense.

After the cribs were placed, clay was deposited along the outer toe, about 1 cu. yd. to the linear foot of crib. Two-inch hemlock sheathing was then driven into this clay and secured by a wale near the top. Care was taken to have this driven sheating break joints vertically with the 1-in. sheathing, previously nailed to the outside of the crib, thus forming double-lap sheathing practically watertight.

The cribs were filled and backfilled with a mixture of earth and loose rock of smaller size.

The cost of the north crib dam, 432 ft. long, was as follows:

Contract dredging, 10,538 cu. yd.	$ 5,286
Materials—timber, iron and clay	5,198
Labor and supplies	6,213
Total cost	$16,697

or $38.65 per linear foot, or $1.85 per square foot of wall.

East Crib Dam.—The embankment originally covering the site of this section was known to be a porous loose rock fill, through which a dry trench could never be excavated. The section was easily accessible for a dipper dredge, and the crip type of dam was therefore adopted. The crib work (Fig. 3) of the north dam continued around the northeast corner and extended to within 4 ft. of the back of the canal pier forming the approach to the Poe lock. This 4x16-ft. space was sheathed and puddled full of clay. The line of steel sheet piling of the "southeast dam" extended 8 ft. into this clay, or to the center line of the cribs, thereby making a good watertight junction of the two types, at the southeast corner.

The east dam (Fig. 3) was 402 ft. long and, except for the dredging, was built by hired labor at the following cost:

Excavation—contract dredging, 15,597 cu. yd.	$10,154
Materials—lumber, iron and clay	4,311
Labor, supplies, etc.	6,200
Total cost	$20,665

or $51.40 per linear foot, or $2.39 per square foot of wall.

North Clay Dam.—This land portion (Fig. 5), 1,300 ft. long, consists of a clay puddle wall, 4 ft. or more thick, built within a narrow trench excavated to rock; except for the uppermost 3 or 4 ft. of wall, it was built without sheathing. The trench, excavated in winter, usually remained dry and stood with nearly vertical sides, the clay being puddled directly into it.

The construction of this north dam demonstrated that certain kinds of work could, under existing conditions, be carried out cheaper in winter. For example: The amount saved in pumping was greater than the added expense of drilling and blasting frozen material. And again, the winter cost of clay delivery, when 5 yd. could be hauled at each load across the ice without rehandling and dumped directly into the trench, was but 40 per cent of the cost for summer delivery. The saving thus effected more than made up for the added winter cost of thawing the clay.

The site of the north dam lay in what was once the bed of the rapids, and at times of high water was partially inundated. To exclude this surface water from the trench, two low embankments, 50 to 60 ft. apart, one down each side of the dam, were constructed of material excavated from the lock pit under a minor contract. As the material was dumped on frozen ground or ice, the embankments proved ineffectual in excluding surface water when most needed, at the time of the thaw-out in the spring. The effect was not serious, as the embankments, built without cost other than for excavation, eventually served as backing for the clay wall.

The site was covered with a layer of boulders large and small, which were removed from an area 40 ft. wide along the line of the proposed dam before starting the trench excavation. Nine men working one month removed 721 cu. yd. of boulders from 1.15 acres of ground, at a cost of 76 ct. per yard, or $475 per acre. Many of the boulders were firmly embedded in gravel and frozen and could have been removed at less cost in summer. The stones were moved an average distance of but 20 ft., and piled along one side of the area. The stones were pried or blasted loose, the smaller ones carried by hand and the larger ones raised with chain falls suspended from a light tripod derrick and lowered onto a hand truck and hauled over improvised plank runways to the dump. Fifty-four of the largest boulders, averaging 2¾ yd. each, were drilled by hand and cracked with dynamite.

A force of 50 hired laborers, many of whom were from the regular lock force, dug the trench through frozen gravel and placed the clay in about four months' time. The trench was from 3 to 15 ft. deep. When a section of trench 300 to 400 ft. long was completed, it was partitioned off with plank bulkheads and filled with clay dumped from sleighs driven alongside. The clay was deposited in layers from 6 to 24 in. thick, depending upon how badly the lumps were frozen, then puddled with hot water. When necessary, the layer of frozen clay was covered with tarpaulins under which steam was allowed to exhaust over night. The puddlers wore rubber boots and used wooden rammers. A 10-HP. portable boiler was used for thawing purposes. Clay for puddling must be a heavy, stick clay, free from loam. For this work an exceptionally good quality of red clay was available in a bank located 1½ miles from the dam. It was loaded and team-hauled under contract. Clay shrinks 33 1/3 per cent from box measure when puddled in place. When the wall projected above the original ground surface it was confined by sheating of second-hand 1-in. lumber, placed horizontally like a fence, the upright posts being braced with short braces. The cost was as follows:

COST SUMMARY.

		Unit.	Cost.
Stripping boulders		$0.76	$ 545
Excavating trench, 2,845 cu. yd.		2.96	
Labor	$7,677		
Supplies	756		
			8,433
Clay wall, 3,000 cu. yd.			
Labor	$2,040		
Supplies	187		
			2,227
Clay, 4,790 cu. yd. box measure		.438	2,099
Backfilling 550 cu. yd.—labor			1,092
Total cost			$14,396

or $10.96 per linear foot, or $0.934 per square foot of wall.

Junction Dam.—A clay puddle wall between 2-in. vertical sheathing, then backfilled. This section, but 30 ft. long, is a continuation of the North Clay Dam, connecting it with the crib, or water, portion. It was built in the summer time at high cost for excavation and for clay. The work performed by hired labor and in the dry, necessitated heavy expense for temporary sand-bag dams around the excavation and for pumping.

West and Northwest Cofferdams.—Preliminary Dike. Means were at hand for building a rock-fill dike across the corner of the head-race, behind which, owing to natural drainage into the tailrace, the cofferdam could be built in the dry. For this reason the type of dam selected was a clay wall rather than the crib type, built in the wet. Considerable saving in cost of cofferdam was thereby effected, especially as the preliminary dike was built by dumping material, then being excavated under contract, without any cost to the United States other than for excavation.

The water was about 16 ft. deep and the dike was from 20 to 30 ft. wide at the water surface.

Unfortunately, an overturned Indian canoe was buried at the base of the dike and considerable leakage resulted. Another bad leak occurred at a point where dumping ceased for a couple of weeks. The finer material was washed from the end of the finished portion, leaving a well-defined plane of leakage. The volume of water coming through become so great that its diversion could not be successfully accomplished, and it became necessary to stockram these leaks with clay before construction on the northwest dam could proceed.

Northwest Dam.—This section (Fig. 6) is a continuation of the north dam, about 190 lin. ft. being a low level clay puddle wall, 4 ft. thick, built within a shallow trench, and about 350 ft., or the high level portion, is a clay puddle wall confined by elaborate timber sheathing set up within an open trench. The wall was afterward backfilled on both sides with loose rock. The work was performed in the summer. The cost of this section was as follows:

Development and incidental labor	$ 605
Excavation	3,744
Sheathing—labor and lumber	919
Clay wall—labor and clay	2,552
Backfilling—labor	1,149
Supplementary work—ramming leaks	1,711
Total	$10,680

Arresting a leak through a rock seam underneath the cofferdam was accomplished by capping the seam with a heavy concrete box from which a 4-in. iron pipe was led upward to such height that overflow into the tailrace was possible. The concrete was anchored firmly enough to resist the pressure due to the head of water—in this instance about 8 ft. This method was preferable to stopping the leak by calking the rock seam, as past experience proved that a leak so stopped would later break out in another place. The box was about 4 ft. square, and the outcropping seam was calked for several feet both sides of the box.

West Clay Dam.—This was a clay wall (Fig. 7) built in the summer. A portion lay in cut where no excavation was necessary, while another part passed through an embankment. The former was built within sheathing held in place by backfilling. The backfill was carried up with the clay, the material being excavated simultaneously from the trench for the adjoining embankment section. The clay, delivered the previous winter to nearby stockpiles, was wheeled to place. A drain pipe for unwatering a nearby pit passed through this dam. The 10-in. pipe was provided with a collar 4 ft. square, made of plank. This collar was so placed as to fall within the limits of the puddle wall. When ready to pump out the lock pit, this pipe was closed by a wooden shutter, and never caused any trouble.

The cost for 258 lin. ft. of dam was as follows:

Excavation	$ 711
Sheathing—labor and lumber	292
Clay wall—labor and clay	1,632
Backfill—labor	572
Total	$3,207

or $12.43 per linear foot, or 97 ct. per square foot of wall.

Southwest Clay Dam.—This short, but high, section of new cofferdam (Fig. 8) connected a long stretch of existing clay dam with the northwest corner of the Poe lock masonry, thereby completing about 1,766 lin. ft. of cut-off wall along the south side of the new pit. It was the only section let as a contract. The contractor failed and the work was completed by hired labor. A trench was excavated through frozen embankment to rock, the sides sheathed with 2-in. hemlock plank, placed vertically, then filled with puddled clay, giving a wall 5 ft. thick. The maximum depth of trench was 35 ft., and the length 179 ft. The cost of this section was as follows:

603 cu. yd. excavation	$1,934
Sheathing—labor and lumber	420
Clay wall—labor and clay	1,102
Total	$3,456

or $19.31 per linear foot, or $0.64 per square foot of wall.

Supplemental Work on Southwest Dam.—An existing stretch of clay puddle wall, known as the "Lally" dam, and which was built in 1895 in connection with the construction of the Poe lock, formed a portion, 548 ft. in length, of the new lock cofferdam (Fig. 9). Owing to its close proximity to the top of slope into the Third lock pit, it was necessary to do some supplemental work along 240 ft. of its length to make it secure against sliding. This work consisted in driving 6x12-in. hemlock sheathing a depth of 22 to 28 ft. to rock along the north, or pit, side of the existing clay puddle wall, and anchoring it back to a concrete canal wall with 1½-in. tierods, spaced about 8 ft. center to center. This protection was also extended to cover a portion of the southwest cofferdam before described. The work was performed by day labor, and cost as follows:

Materials—timber and iron	$2,550
Labor, placing	1,747
Stockramming leak with clay—labor and clay	375
Total	$4,672

or $12.24 per linear foot of wall sheathed.

Costs.

The last column of Table I gives the cost per square foot of vertical face area of completed wall. This unit cost seems the best basis of comparing the relative cost of the different types. It will be seen that simple clay puddle walls, without sheathing, cost 93 to 97 ct.

The southwest dam cost only 66 ct., because considerable work was done by bankrupt contractors without cost to the United States. If the United States could have been held liable, the cost would have been 96 ct. per square foot, the same as for other clay walls.

The northwest dam cost $1.38 because of the water troubles and burden of stockramming leaks, and because of the high cost of summer delivered clay and its subsequent rehandling. Could this section have been built in the winter time, its cost might have been much less.

The short junction dam at $2.78 carries a large burden of overhead expense, and it is unfair to draw comparisons of cost. It is possible that steel piling could have been used at a saving in cost.

The southeast dam at $1.62 is high, because of the elaborate sheathing employed; no especial difficulties being encountered in its construction.

The crib dams are relatively expensive, because of the amount of material used in their construction and the difficulty in getting the cribs in good contact with the rock bottom. The north dam cost $1.85 per square foot against $2.39 for the east dam, the difference being due entirely to the larger quantity of excavation necessary for the latter section.

The cost for the heaviest (40 lb.) steel piling driven through 25 ft. of hard driving (boulders, gravel and hardpan) was only 96 ct. per square foot. This makes it a formidable rival of the clay puddle wall. Its use at this locality was an experiment and, had its possibilities been as well known then as now, several other sections of dam might have been built of steel sheet piling at a considerable saving in time and probably in cost.

The efficiency of the different sections of cofferdam has been first class. The only leaks were a small one under or through the east crib dam, and another, amounting to enough to fill a 3-in. pipe, under the steel piling of the southeast dam, where one piece of piling evidently struck a boulder. The only money paid out for maintenance by the contractors was in connection with the latter leak, when the masonry contractor bore the expense of a few days stockramming, amounting to about $346.

A leak of considerable size developed through a rock seam under the southwest dam. This leak probably occasioned 75 per cent of the required pumping and both the contractor for excavation and the contractor for masonry spent considerable money in unsuccessful attempts to stop it. This leak is not chargeable to inefficiency of cofferdam, however.

Pumping—Quantity and Cost.

The pumping plant was installed by contractor for excavation and the pit first unwatered on Sept. 26, 1909. At the expiration of his contract the plant was purchased by the masonry contractors and operated by them directly until June 19, 1914, and as subcontractors up to Aug. 1, at which time the pumping was taken over by the United States.

TABLE I.—SUMMARY OF GENERAL DATA AND COSTS OF COFFERDAM INCLOSING LOCK PIT AT SAULT STE. MARIE, MICH.

Date of construction.	Name of section and kind of construction.	Actual length constructed.	Average depth of excavation.	Normal head of water pressure on deepest part.	Average height of completed wall.	Actual face area of completed wall.	Costs (from engineer's data). Total actual cost.	Unit cost. Per. lin ft. of wall	Per sq. ft. of wall
		Feet.	Feet.	Feet.	Feet.	Sq. Feet.			
November, 1908, to May, 1910	Southeast cofferdam—two sections:								
	Clay wall and oak sheet piles	144	10.2	17	20.9	3,015	$ 4,900	$34.02	$1.62
	Steel sheet piling	265	....	22	25	6,625	6,365	24.02	.96
June, 1908 to May, 1909	East crib dam	102	22	21	21.5	8,653	20,665	51.40	2.39
June, 1908, to February, 1909	North crib dam—timber	432	13.5	23	20.9	9,041	16,697	38.65	1.85
November to December, 1908	Junction dam—clay wall	30	....	18	16.6	149	1,251	41.70	2.73
December, 1907, to January, 1909	North cofferdam—clay wall	1,313	8.6	14	11.8	15,460	14,396	10.96	.93
June, 1908, to October, 1909	Northwest cofferdam—clay wall	539	6.7	13	14.4	7,709	10,680	19.79	1.38
March, 1908, to January, 1909	West cofferdam—clay wall	258	8	10	12.8	3,298	3,208	12.43	.97
March, 1908, to April, 1908	Southwest cofferdam—clay wall	179	30	29	30.3	5,228	3,456	19.31	.66
November, 1909, to May, 1910	Supplementary work:								
	Lally and southwest dam:								
	Fir sheet piling and tie rods	351	....	..	26.5	9,298	4,297	12.24	.....
	Stockramming leak	100	....	..	....	......	375	......	...
Grand total		.....	....	..	....	63,776	$86,290	......	$1.25

The battery of pumps originally installed was as follows:

One 10-in. centrifugal with 100-H.P. motor,
One 8-in. centrifugal with 85-H.P. motor,
One 6-in. centrifugal with 50-H.P. motor,
One 5-in. centrifugal with 20-H.P. motor; and
One 4-in. centrifugal with 15-H.P. motor.

The maximum battery required at any one time consisted of the four latter pumps, the 10-in. being a reserve unit for emergency.

The volume of pumping varied from a minimum daily average of about 850,000 gal. in winter, while the adjoining canal was unwatered, to a maximum daily average of about 3,000,000 gal. during the summer. The maximum for any one day was about 4,000 gal.

Cost of Pumping.—Under the contract for excavation there was pumped (during 757 days, between Sept. 26, 1909, and Oct. 23, 1911), 1,242,628,000 gal., at the following cost to contractor.

Labor		$11,428
Electric power (at 1 ct. per k.w. hour)		6,975
Fuel		403
Supplies		398
Repairs		147
Overhead charges:		
Installing plant	$ 314	
Interest and depreciation	2,151	
		2,465
Total cost		$21,816

or $0.0176 per 1,000 gal., or $28.90 per calendar day.

Under the contract for lock masonry, the pumping during 858 days (Oct. 23, 1911, to March 1, 1914), amounted to 1,094,760,000 gal., and cost the contractor as follows:

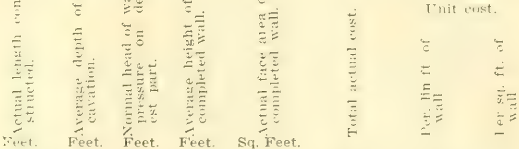
Labor		$12,208
Electric power (at 1 ct. per k.w. hour)		8,221
Supplies, fuel and repairs		2,052
Overhead charges:		
Interest and depreciation	$1,012	
Dismantling (assumed)	300	
		1,312
Total cost		$23,793

or $0.0217 per 1,000 gal., or $27.85 per calendar day.

BUFFER TO HOLD CARS ON INCLINE.

In many quarries cars are hauled to the top of inclined tracks by a cable or, more commonly, by means of a mule. While the necessary change in cable attachment is being made the wheels may be blocked with a piece of wood or stone placed on the rail. This is not a secure means of holding the car, as the block may slip or be accidentally removed, permitting the car to start before the controlling cable is attached. An efficient means of preventing such accidents employed at a Pennsylvania ganister quarry is described in a recent bulletin of the U. S. Bureau of Mines on Sandstone Quarrying in the United States. The arrangement consists of a timber block which rises from a depression between the rails and meets the buffer of the car. When the car is ready to descend, the timber, controlled by a lever, descends into a pit out of the way.

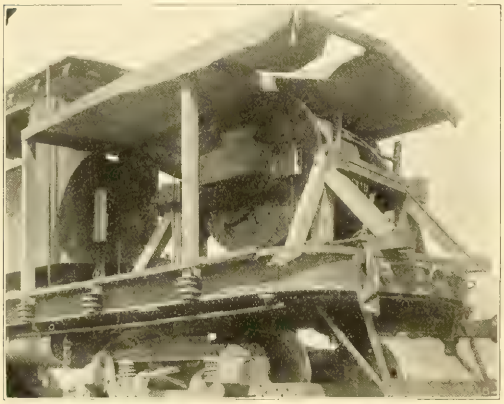
As an additional precaution a derail is placed a short distance from the top of the incline. With a three-rail system the derail should be on both outer rails. To be most effective it should slide toward the center rail. It thus forces the car outward, directs it away from the track, and causes it to travel where it can do the least damage. The derail is thrown until the car begins to descend and until its safe control is recognized; the derail is then thrown into place by a lever before the car reaches it.



Timber Buffer to Hold Loaded Car in Place.

ELECTRIC DITCHING MACHINE ON RAILWAY CONSTRUCTION.

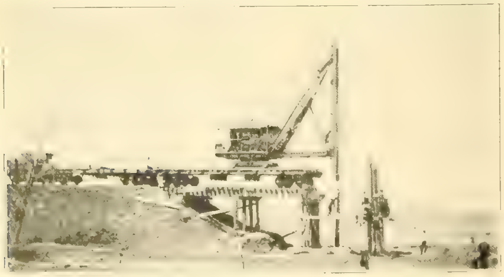
An excellent demonstration of the possibilities of electrically operated equipment was given last year in the construction of an electric railway from Edmond to Guthrie, Okla., by the Oklahoma Ry. Co. A large portion of the construction work on this new line was accomplished by means of an American electric ditcher made by the American Hoist & Derrick Co., St. Paul, Minn. This machine was employed not only on grading, but it also was used on the track laying, the building of trestles and other operations.



Arrangement of Reel and Trolley Line on Work Car.

The ditcher was worked in advance of the construction of the pole line, the electric power for operating purposes being obtained through a cable carried on a reel on the motor car which propelled the work train. The arrangement is described in the American Ditcher Scoopings, from which the matter in this article is taken.

The reel was a heavy wooden one such as is used for shipping wire rope. It was mounted on a heavy frame of oak timbers so that it would turn freely. A belt was put over one flange of the reel, by means of which a 5-HP. motor wound up the cable. A large steel plate was bolted on the other end of the reel for contact to the ditcher. The end of the cable was run out through a hole in the end of the reel and fastened to the contact plate with a bolt and two copper washers. A circuit breaker was placed on the line to the ditcher. As the ditcher necessarily worked on the front end of the train, while the work car was in the rear, with usually seven cars of material between, it was necessary to provide jackknife connections between cars in the feed wire to the ditcher. This made a switch necessary on this line so that the current could be shut off while the connection was being broken, which was done whenever it was desired to cut out empty material cars. The circuit breaker was used as a switch when it was desired to break a connection. There was a controller on the work car for the motor which wound the reel, and there was another circuit breaker for this. Current was taken from the end of the trolley line by means of a hook attached to a pole and hooked over the trolley. The work car then pushed its train out to the end of the newly constructed track paying out the cable as it went.



Ditcher Driving 26-Ft. Piles.

About 1,000 lin. ft. of trestle were constructed by means of the ditcher. In this work the dipper handle and dipper were removed and wooden leads suspended from the point of the boom, as shown in the accompanying illustration. One 15-bent trestle with piles 28 to 54 ft. in length and a penetration of from 7 to 13 ft. in sand and shale was completed ready for traffic in 6 days. The ties, stringers and rails were placed by the ditcher. The labor cost of the 1,000 ft. of trestle was $3.12 per lineal foot. This includes wages of bridge men, driver operator and helper and work train crew. It also includes handing the material in the yards and transportation from the yards to the site of the work.

For laying track and setting trolley poles the work train usually was made up of two cars of steel (next to the ditcher), three cars of ties and a car of poles. The angle bars were bolted to the ends of the rails in the yards, so that when laying them all that was necessary was to slip in the bolts. The rails were not spiked down when first laid, but were held in gage by bridle rods, and only enough ties were placed to permit the passage of the work train, another gang placing the rest of the ties and spiking the rails to them. A center tong was used for handling the rails, the centers of the rails being marked with chalk before leaving the yards, to insure fast and accurate centering.

Work Train with Reel Car in Rear.

The ties were put up in wire slings, 18 ties—enough for one rail length—being put up in each bundle. The material cars were loaded at night by the ditcher.

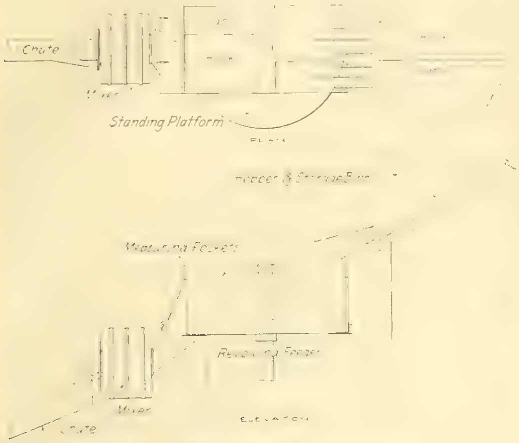
The trolley poles were all set by the ditcher, the method being to put a chain around the pole so that it nearly balanced when lifted. Two men on the ground with cant hooks roughly set the poles, which were placed in holes previously dug. They were then trued up and permanently set by the regular pole gang when it came along.

Quarry Stripping with Overhead Cableway.—An overhead cableway is used for stripping at a sandstone quarry near Peninsula, O. The soil stripping is 7 to 15 ft. thick and is stripped back into the old quarry pit. The cable is $2\frac{1}{2}$ in. in diameter and 900 ft. long, the distance between the towers being 650 ft. Each tower consists of a pair of timbers converging toward the top and braced with cross timbers between. The cable passes over the towers and is anchored at the ground at some distance back of them at either end. The usual system of buttons and stops is employed to hold up the slack of the cable. Large pans are loaded by hand shovels, removed by the cableway, and dumped.

REVOLVING FEEDER FOR CONCRETE MIXER.

Contributed by James C. Foss, Jr.

The accompanying drawing shows a method of feeding a small mixer which is not equipped with a pivot hopper, so as to eliminate time loss and still have an accurate measurement of the aggregate. The general rule is to feed a small mixer with wheelbarrows and measure the materials by calibrating the barrow, but the results by this method, including the personal equation of tired, hurried labor used in filling the wheelbarrows, are sometimes very far from the mix intended. By using the revolving wheel with the stone and sand pockets and trip latched doors the full quantities for a batch can be dumped simultaneously into the mixer, and while this is being done the opposite empty pockets can be filled. The cement is introduced by dumping from bags on top of rock bin as the rock goes out the door. With a 4½ cu. ft. mixer an average of 50 cu. yd. of concrete can be poured in a 9-hour day.



Revolving Feeder for Small Concrete Mixer.

BREAKING UP LARGE BOULDERS BY HEAT.

An oil burner torch was used by the New York Subway Construction Co. in breaking up large boulders encountered in connection with its subway work in New York City. One of these niggerhead boulders, 8 ft. high and 10 ft. thick, was uncovered near the Borough Hall in Brooklyn. Owing to local conditions, the use of dynamite was prohibited. The contractor therefore decided to use a Hauck oil burner, and by playing the concentrated flame on one spot on the stone for 10 or 15 minutes the rock was split at the seams. By repeating the operation it was reduced to a size that could be handled conveniently. The boulder was broken up in about one hour at a total cost of approximately 60 ct., this including the 1 gal. of kerosene consumed by the burner and the part time of two men.

Breaking Up Boulder with Oil-Burner Torch.

THE ENGINEER IN POLITICS.

The coming of more ordered and settled economic conditions in the country and the intensified needs of the municipalities following the unmistakable movements of population toward the centers of trade have awakened at last the livliest interest in municipal affairs, bringing with this an insistent demand for clean and effective government. The phenomenal growth of this interest, however, has not allowed sufficient time for the development of a supply of men to carry out and develop the new idea of government. No movement which has had so stormy a beginning, which has been so full of sorrows and disappointments, which has had its birth in such low conditions can prove to be without its serious faults and defects. The errors thus far made are legion; the failures enough to discourage the most hopeful. It has been most unfortunate that the notion has more or less prevailed that the mere raising of a banner and the recitation of the wrongs of man will serve to collect and make complete a revolution in affairs. Just as little does this cry of civic righteousness bring real leaders. The public has often been gulled by the schemer and men are not fully ready as yet to agree that the public desires honesty and efficiency—in fact, there is a good reason to think that the government service is still the happy hunting ground for vested interests and for personal gain.

The Engineer a Pioneer.—The first demand in any movement is for men who will be pioneers, who, full of enthusiasm for the public service, are willing to suffer unjust personal attacks, yet who will move forward to a great end. Although party has no place in municipal affairs, the old idea is still existent that men serving cities should also serve their national parties. The sole reason, however, for the formation of a city is business expediency and so its concerns are business concerns and not matter of national policy. Certainly, under present conditions, large personal gain may not be expected from public office, and until men of great skill and earning capacity come to appreciate the great honor of serving their community, the public must be content with securing men of average attainment to conduct its municipal affairs. Business efficiency and a well-balanced nature, unmoved and unconfused by the haulings of selfish interests, are the basic qualities of those to whom should be entrusted your affairs and mine. The question now arises. Where must men approximating this standard be sought, and how best may they be attracted to the public service.

Fitness by Training and Accomplishment.—Latterly, the public has taken a wholesome interest in the experience and private character of those who would have its favors, much to the disgust and discouragement of those who prefer the soft and favoring shadows. As in the cure of bodily disease, light has been a most effective cleansing agency, for it shrivels up and destroys the unfit and the noxious. Comparatively few men, thus far, have sought office staking their claims to public attention upon their business records and private reputations, and, as a rule, only when hard pressed in a bitter campaign, have political parties made the issue of an election on the personal attainments of their candidates. Therefore, the engineer, with a tendency to retire to his workshop, has had little opportunity to be considered as possible political timber and his attempt to win public favor has, in large measure, been viewed as an amusing interlude. With the wholesome wave of interest in municipal affairs which followed the disasters of Galveston and Dayton, the public at last seems to have been impressed with the peculiar fitness of engineers to handle emergencies and to set in motion measures of relief. The mere presentation of this favoring field, however, is not sufficient to supply the men and they, themselves, must prepare to accept the invitation to

From a paper by Robert G. Dieck, Commissioner of Public Works, Portland, Ore., in the June Journal of the Oregon Society of Engineers.

office—in a word, they must subject themselves to a period of preliminary training.

It is presumed that the engineer entering politics has secured technical education and considerable experience. This experience need not be too specialized, but it should lie in the direction of municipal improvements. The tests applied in other branches of engineering are not strictly applicable to the case in point for the reason that the results are not as closely scrutinized as those in the municipal field. It is beyond reason to expect that the engineer-administrator will have adequate time to discuss the details of construction proposed, or that he will go afield to direct construction operations. Essentially he must be the directing hand for policies, and, therefore, should be relieved of extended detailed examinations of plans or work under way. However, many cases arise in which decision must be made and in such cases his technical knowledge in the governing body will prove of unquestioned benefit. The great danger arising from too close attention to details is that the needs of the city other than those of the unit under his direct control may not be sufficiently emphasized or appreciated. A well-balanced administrative body should not consist of specialists who are so wrapped up in particular work that they may lack appreciation of work in other units of the government, and, therefore, what indifferent successes have been made by engineers in administrative positons, appear to flow from too close specialization or failure to regard all activities of the government as independent and inseparable. This is a pitfall which it is proper to avoid, but which over-zealous officials rarely sense. It is an unfortunate criticism of engineers that they are prone to indulge in pursuits of their specialty, and therefore, when questions of vital importance arise they are unprepared to meet the larger needs of the community.

Elements of Law Essential.—It passes beyond argument that every administrator should be possessed of a basic knowledge of the elements of law. He should not only know the method of enforcing compliance with contracts, but also in an emergency should be able to found his argument or action upon sound legal principles without feeling need of consultation with the attorney. The engineer being experienced in the drafting and execution of contracts, and trained in logical thinking, is at a positive advantage, in this particular, over men of other professions. There are, however, many other forms of legal documents which must pass through an administrator's hands and, though competent legal advice may be available, it is not always expedient or safe to accept, unquestioned, the opinions of the legal adviser. In many cases the assistance of the legal adviser is purely technical and has little effect other than to harmonize the structure and wording of the legislation sought to be enacted. Many cases arise where, through the expedient of formal agreements, it may be necessary to proceed against violators of laws, and such papers may often serve the occasion without any review by attorneys. If nothing else, a short course in the study of law is of unquestioned value and will prove a happy possession on many an occasion.

Reasonable familiarity with methods of administration of police, fire and health bureaus should be had by the public official. Emergencies touching these constantly arise and unless the vision be large and expedients used elsewhere be known, the issue may not fairly be met. The essentials of organization of such bureaus are presumed to be known to any person desirous of accepting public office though the public has not always been fortunate in having its servants so equipped. Unless the the officials through reading, observation and experimentation, inform themselves of new methods and possible improvements in service, there is grave danger of stagnation of these activities and the lowering of efficiency in administration generally. Of course this observation applies equally well to all units of the government and is not particular to the measures set on foot for public safety, but in the past there seemed to be something of obscurity attaching to such functions. The construction program for fire buildings, the time for replacement of equipment, and the establishment of health laboratories, are all subject to rigid rules both as to expediency and as to proper financing, and there the analytical mind of the engineer should very properly be called to aid.

The ever widening field of public service utilities bringing to attention the major matters of rate regulation and possible absorption of all such conveniences by the government, opens an attractive opportunity to the analytic, technical mind. The literature on this subject has recently taken almost decided technical tone, with the result that where before the lawyer had first place, the opinions and arguments of the engineer are now strongly emphasized. With the years it is quite probable that the public will assume all management of utilities, both for its better protection and for the winning of all profits, and wherever the public tendency is manifesting itself, the engineer should urge his nomination to office. The study of the question will still further require preparation in the law—it is true, along specialized lines, but of immediate usefulness. Even without municipal ownership of utilities, the discussion of franchise grants must be based upon knowledge of law and the determination of adequate and just compensation for such grant is essentially a problem in engineering.

Every engineer appreciates that oft-forgotten truism that no project may have successful issue unless its conduct be along sound financial lines. In an honest private enterprise no step is taken until the whole subject is reviewed and an ultimate profit is assured. Unhappily, in matters of public concern, less emphasis is given to futures and as a result public improvements of almost every kind are embarked upon in an effort to win favor and applause through compliance with popular demand, with little real regard to the outcome of the venture. It has been a just criticism of American municipal governments that in periods of prosperity or booms they rush into ventures which in lean times bring the electorate to undue exercises of profanity. In short, the American municipality has been like the savage—a glutton in plenty who faces starvation and extinction in famine. No city has escaped the burden of unwise developments and the inevitable, bitter pay-day.

Engineer's Discernment.—The training of the engineer will allow him to divert attention from ill-conceived and profligate schemes and to support and urge only the profitable and sound. His skill should be lent in opposition to proposals set in motion by specious argument. The whole field of politics is full of men who seek to advance their ideas by every argument possible, sometimes without strict adherence to the rules of logic or to truth, and it then becomes the grave duty of the engineer-administrator to shatter idols and to strip off the blinds. Of course it will be hard to resist the yelpings and demands of special interests, and the persistence of demagogues, but if he is to succeed and be true to himself, the administrator must be prepared to withstand, unmoved, the shock of selfish argument, and to turn back the assaults of those seeking personal advantage. Certainly the skill which impels a client to agree in an outlay of funds for a private enterprise must be of direct and positive value to the public client and this is what the engineer presents.

Grounding in Finance Important.—It behoves every intending administrator, therefore, to prepare himself in finance. In a short time he will be led into the most interesting fields of financial expedients—bond issues, sinking funds, loans, allotments to depreciation and obsolescence funds, revenues, expenditures, capital outlays —rows on rows of worthy antagonists for the keen-trained. These again develop discussion of the proper accounting and control methods, with their infinite refinements and niceties. It has been said that governmental business methods may and should be like private business and that if they be unlike these, then there are ills of government in need of drastic treatment. If it be considered that private business has a single head and its conduct to please its few owners only, and that the public business is of each one of us—qualified or unqualified to be conducted distinctly as each one of us free agents desires, the task of satisfying all citizens is not of the nursery. The constant interference of self-constituted, "more or less" specialists, is a positive bar to economical administration or finances, and so, again, the engineer with his precision and directness of thought can be of positive value in governmental control if he devise and establish less cumbrous accounting methods. I have often wondered why the engineer has not been attracted to finance, for assuredly he has the temperament which qualifies him for finance.

Perhaps it may be his desire to see the physical form of his visions rather than to wait for gains, or that he does not adopt it as a specialty because it has not been done and would be an improper invasion of other professions.

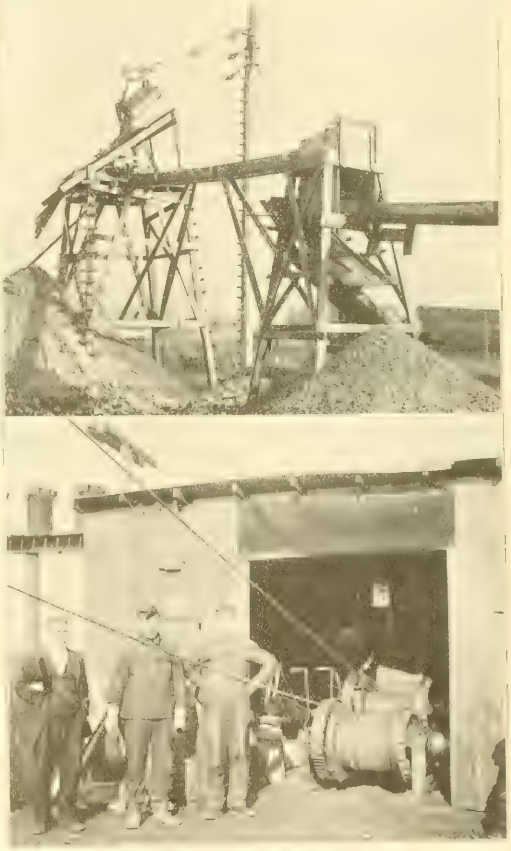
Thus far we have dealt only with material things—roads, utilities, and etc.—but upon these alone no city can endure and grow. No collection of men in that complex organization called the city can long hold together unless it be cemented by human sympathy and live social interest. The city is a community—a gathering of men with a common aim, gaining strength with the city's growth—and so we must come to recognize that there is something in the city above bare construction and schemings, and above cold figures and lifeless statistics. There is the individual citizen who needs the protection of the whole community and is entitled to have the government guard the morals of his children, amuse him decently, encourage him with things of good taste and of uplift—in short, make him a citizen. This leads easily to the stupendous question of proper amusements as touching all these duties of government—the establishments of parks and pleasure resorts with their thousand and one possibilities, the institution of music festivals and concerts, the improvements in tone of motion picture exhibitions, the encouragement of city pageants and clean drama, the fostering of a real civic art. The mere mention of these is enough, but unless the engineer really appreciates those needs more than his buildings and plannings, he cannot be a successful administrator and has no right to control the destinies of his fellow-citizens. If, without complaint, he will not accept the postponement of his most cherished schemes and will not allow something of real human importance the right to place, when funds are low, then he is a flat failure and merits no public attention or favor. The restraint which this giving over imposes may prove most annoying if much effort in preparation will have been made, but the defeat will broaden and strengthen the human interest of the vanquished. It is often said that the engineer unduly chafes under interference with his proposals, that he drives from his work the smallest semblance of sympathetic consideration. This evil reputation—I am sorry to admit—is sadly too real a thing and so before he can reach highest service to his fellows he must spend more time in that school of all schools—the world of sympathy and humanity.

Reducing Wear on Chains in Handling Quarry Stone.—A Connecticut quarry company employs the following method in handling blocks of stone with chains. The chains are passed completely around the sandstone blocks, which are then hoisted from the quarry, and when the blocks are placed on flat cars the chains are left around them, a separate chain being used for each block. When the blocks are taken to the mill or yard, it is a simple matter to hook into the chain already attached. This plan saves much time and also reduces the wear and tear on the chain.

GRAVEL PLANT SUBSTITUTES ELECTRICITY FOR STEAM POWER.

The high cost of coal is causing sand and gravel plant operators to give more attention to ways and means of utilizing electricity for operating their excavating, washing and screening machinery.

In the case of the Capital City Gravel Co. of Indianapolis, Ind., the change from steam to electric motive power was made when a new plant was erected. In the new plant a dragline cableway outfit with a 1-yd. "Pioneer" excavator bucket is operated by a Thomas two-speed 55-HP. electric hoist and the water for sluicing and washing the material is pumped from the river by a centrifugal pump driven by a 20-HP. motor. The pump will furnish 500 gal. a minute against a 60-ft. head.



Washing Plant of Capital City Gravel Company and Electric Hoist Which Cuts Operating Costs.

The use of the electric hoist cuts one man off the payroll. The new plant requires two men; an engineer and a helper who acts as a handy man around the plant and relieves the operator at the hoist. The old steam-operated plant required three men—engineer, fireman and helper.

In addition to the saving in labor, the cost for power per yard excavated is less under the new method. Mr. C. W. Stevens, manager of the Capital City Gravel Co., says his monthly power bills average less than the monthly coal bills of 1913 and 1914 when he was operating another plant which had the same average monthly output. Besides, he says, he has done away with expensive boiler repairs and delays on account of such repairs. There are no waits to get steam up; the electric hoist is ready to commence operation in one minute at any time.

PROPOSED $1,000,000 COAL-CARRYING CANAL FOR ILLINOIS.

The construction of a navigation channel as a measure for reducing the difficulties and cost of transportation of coal from the Southern Illinois fields to the Mississippi River was proposed by a bill submitted at the present session of the legislature of Illinois.

The tentative plan, as outlined in the report of the Illinois Rivers and Lakes Commission, submitted last February to Governor Lowden, contemplates the construction of an artificial canal of 8 ft. minimum depth, from Fountain Bluff on Mississippi River to Sand Ridge on Big Muddy River, a distance of 6.5 miles, and the canalizing of the Big Muddy from Sand Ridge to the C., B. & Q. R. R. bridge above Plumfield, a distance of about 55 miles.

The principal construction features involved in the carrying out of this plan are: Lock and spillway at Fountain Bluff; canal prism, Fountain Bluff to Sand Ridge; stream entrance into canal prism for Kincaid Creek below Sand Ridge; lock and dam at Sand Ridge; snagging and shallow dredging in Big Muddy River.

The junction of the new canal with the Mississippi will be effected by constructing a lock 310 ft. x 45 ft. having a maximum lift of about 30 ft. on the steep face of a rock bluff which forms the east bank of the Mississippi. Approach walls, or docking, will be provided both above and below for the mooring of boats, and a spillway above the lock for controlling the stage of water in the canal. The crest of this spillway will be at elevation 360.0, U. S. G. S. datum, and of sufficient length to accommodate the flood flow of Kincaid Creek which enters the canal near Sand Ridge.

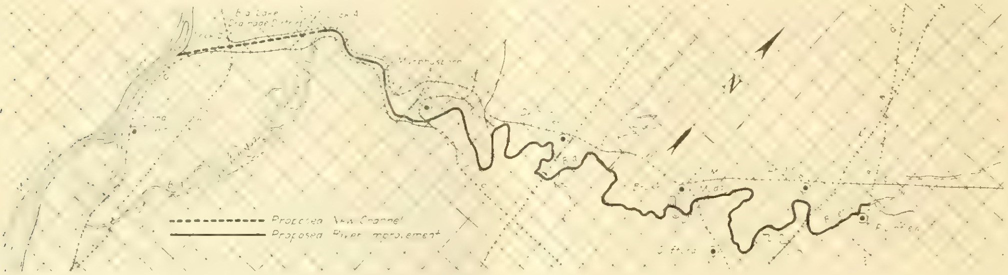
The ground between Fountain Bluff and Sand Ridge, through which the new canal is projected, is nearly level with an average surface elevation of about 360.0, and the material is, for the most part, soft and easily excavated. A prism of 75 ft. bottom width with 2 on 1 slope will probably be sufficient to meet the conditions of navigation. The material excavated will be placed in embankment along the sides of the prism to protect the canal during the flood stages of the Mississippi and dive culverts will be provided to carry drainage ditches and small water courses under the canal.

Means will be provided to empty Kincaid Creek, which now flows into the Big Muddy below the site of the proposed dam, into the new canal. This will probably be accomplished by the construction of a settling basin at the junction to prevent the formation of a bar in the canal. Kincaid Creek is of a torrential character and will require further study to determine the best design for this entrance.

The proposed canalization of the Big Muddy will be affected by building a dam across the valley at a point about ¾ mile above Sand Ridge, where the river breaks through the rock bluffs which form the easterly limits of the broad Mississippi valley. At this point the Big Muddy valley is narrow; the banks are high and steep; and a natural rock foundation for the entire structure is available. This dam will have a length of about 320 feet and an average height of about 25 feet. It will be so designed as to afford the maximum possible capacity for passing flood waters and at the same time guard against loss by leakage during the season of small flow.

At the north end of the dam, where the new canal enters the Big Muddy, a lock will be constructed to prevent the flooding of the canal when the water in the pool above the dam is higher than elevation 360.0. This structure is made necessary by the fact that, during extreme flood the water in the pool above will reach an elevation of at least 370.0. At ordinary stages the lift of the lock will be not over 2 ft. and during low water the gates may be left open and boats allowed to pass directly through.

Little or no work will be required in the canalized section of the Big Muddy from the dam up to a point about 32 miles upstream where three cut-offs are proposed at sharp return bends. In the upper four miles of the project a small amount of dredging will be necessary ranging from 0 to 4 ft. in depth, and some snagging will probably be required through the upper 20 miles of the course.



Map of Big Muddy River Showing Proposed Navigation Canal from Mississippi River to Coal Fields of Southern Illinois.

The estimated cost of the project is as follows:

Lock and spillway near Fountain Bluff	$325,000
Canal from Fountain Bluff to Sand Ridge	170,000
Dam and lock at Sand Ridge	270,000
Stream entrance, Kincaid Creek	15,000
Dredging and snagging in Big Muddy	60,000
	$840,000
Estimated land damage	150,000
Total cost	$990,000
Average cost per mile	$16,100

Cost of engineering and contingencies included in above.

Disposal of Mill and Quarry Waste.—In quarry operations there always remains a certain residue of waste that can be neither eliminated nor utilized. A common method of disposing of the material is to dump it into abandoned piles or to return it to worked-out parts of the excavations. For this work dump cars tripped automatically or by an operator are commonly used. One Ohio quarryman uses the following method for conveying waste to the center of large excavations, where work is being conducted at the same time at various points along its walls. Heavy sheet-metal spouts in sections about 20 ft. long are attached to two parallel steel cables attached at the upper edge of the excavation, and slanting downward to points beyond where waste is to be dumped. The contents of waste boxes are dumped into these slides, and the material is thus conveyed to points beyond the reach of active quarry operations. The point at which the waste falls may be varied by changing the position of cable attachment, or by adding or removing sections of the spout or slide. This method is much more economical than loading waste in railway cars and removing it to a favorable dumping ground at some distance from the quarry.

Derrick Hoist Cable Supported Above Ground.—In some quarries, where a stiff leg derrick is employed, the hoist cable between the hoist shed and the derrick is passed over rollers about 20 ft. above the ground. This arrangement keeps the cable out of the way and renders it safer than those working nearer the ground.

IMPORTANCE OF GOOD FOUNDATIONS FOR LEVEES.*

There is one feature in connection with any levee location that has always been important, but with the increased height of floods has become of supreme importance; that feature is the foundation. During the early history of levee building the basins above Louisiana were open and acted as great reservoirs; in fact, they formed the only possible effective reservoir system for the lower Mississippi. Levee work was disorganized. Although the floods were of moderate height, the great problem was to get levees high enough. A levee overtopped by a stream of water is certain to be destroyed. Hence, the levees were built with an eye single to height and foundations were neglected. The better organization of the work caused more attention to be given to the proper design. The closing of the basins, destroying the reservoir system, gave increased flood heights. For a considerable period height was still the great problem, but new problems were presented. High levees would slough if built of the same form as low ones, necessitating the redesign of the sections. The grosser defects of foundations became evident and caused attention to be given to them. Gradually the levees have been brought to a height where that factor no longer governs. Steadily the levees are being brought to both a height and section where neither of these factors will cause anxiety. The work has progressed so far and the methods of high-water protection have been so improved by the introduction of floating levee machines that the district officer has little to fear from danger of overtopping or sloughing. As the levees proper have improved, the floods have been better confined, have reached greater heights, and have given an increasingly severe test of the foundations. Since 1900 there has been but one important levee failure (Torras) between Vicksburg and New Orleans from any cause except weakness of the foundation. The custom was formerly to ascribe these failures to gross defects in old construction, such as logs and roots left in the base, and, doubtless, some failures were due to such causes, but failures occurred where there was no evidence of gross defects in construction. The great floods of 1912, 1913 and 1916, exceeding all previous records for height, gave an exceptional opportunity to study the causes of failure.

Three crevasses occurred in the same manner and in three levees built on almost identical foundations; Hymelia, Lake St. John and Buckridge. In each case the trouble appeared suddenly as a leak from the ground at some distance in the rear of the levee and worked rapidly back to and through the levee. For a short period each levee remained as an arch over the crevasse. Each levee was built along an old bed of the river. Previous to the breaks, the levees gave no trouble, but the whole country in the rear of them seeped freely. In the case of Hymelia there was doubt as to the construction being good. At Lake St. John there was strong presumptive evidence that there were no gross defects in the levees proper. The great gulches cut by both the crevasses destroyed any chance of studying the foundations as they existed formerly. At Buckridge the crevasse scoured out a pot-hole about 80 ft. deep, but this hole extended only a short distance back of the break. Beyond that the ground was intact and could be studied.

Buckridge Levee was built by a distinguished officer of the Corps of Engineers, who later became its chief. The levee was enlarged by another officer who had much experience in levee construction. The assistant engineers and inspectors on the work are all men of the highest standing in their profession today. Nothing was lacking of skill in the design or of care in the construction. The conventional 4-ft. search-ditch revealed only the finest buckshot foundation. The construction has been exposed by the break and is such as might give satisfaction to any builder. The old levee is homogeneous and compact. In tearing down 200 ft. of it to get earth for a new levee, not a sign of any vegetable matter or other defects was found. The levee is a tribute to the scrupulous care of its designers and builders. The material is buckshot. Four days before the break the writer examined this levee and found no defects. At midnight of Feb. 14 the levee showed no defects when the mounted patrol passed. Two hours and a half later the mounted patrol returned. The night sentinel reported a leak that had been running in the field, about 30 ft. back of the levee, for about an hour. The patrol left his horse on the levee and went to examine the leak. A second leak broke out nearer the levee. The patrol went to examine it when the leak broke out like a geyser, so suddenly that the patrol was drenched. As he ran for the levee the crevasse occurred, leaving him on one side and his horse on the other.

Knowing the foundation to be bad, the writer caused a search-ditch of unusual depth to be cut along the line of the new levee built to close the break. This ditch showed everywhere, except directly opposite the break, a layer of buckshot from 6 to 8 ft. thick. Directly opposite the break is a short stretch where the top layer is loam. Under the whole stretch is quicksand, into which a 3-yd. clamshell bucket sinks 11 ft. of its own weight. This quicksand flows to the bucket almost like a liquid. A slight head of water in the crevasse hole, 250 ft. to 300 ft. distant, causes typical sand-boil ebullitions in this material. Back of the old levee there existed a growth of willows and cottonwoods. From this information it would appear that the water under pressure found its way between the sand and the buckshot, possibly traveling part of the way along the line of a root after passing the levee. The pressure of the water probably arched the ground surface somewhat, giving a large channel through which water could flow when the surface was broken. So long as the crest was firm buckshot it resisted the pressure of the water, but when the loam was reached the water broke through. A flow once established, the surface layer was rapidly worn away.

This theory is supported by the action at L'Argent and Kempe levees during the high water of 1916. At L'Argent the conditions were the same as at Buckridge, except there were no trees near the levee and no streaks of loam in the surface layer. One sand-boil broke out in the levee and another farther downstream and about 60 ft. from the levee. The first boil was promptly hooped and gave no more trouble, but the second was obdurate. The writer spent the next day at this levee and observed the action. During the night a second boil appeared between the first and the levee. These boils ran about 200 second-feet of water, which carried away the sand rapidly. The whole country was seeping freely. The inner boil showed several distinct craters. Samples taken of the output showed bits of buckshot with the sand. On a line from the levee to the boils the ground had the appearance of being slightly raised. Whether this irregularity was natural or due to an arching of the crust can not be definitely stated. The writer inclines to the latter belief, because the boils were all in line, as if breaking through the crown of an arch. During the day a third and a fourth boil broke out on the same line, each closer to the levee than the one preceding. The writer saw the third boil appear. Without any warning, water burst out like a fountain and sand commenced to flow; eventually, the whole surface of the ground back of the levee was a mass of sand boils. Any weak spot, such as a streak of loam in the surface, would probably have caused a crevasse before the area was inclosed by a cofferdam.

The action at Kempe was very much the same. A number of sand boils appeared. The sand which flowed overnight from one great boil amounted to more than 1,000 cu. yd. Apparently this sand came from under the levee and left a cavity. The banquette broke and sank, as if into a great void, and sand temporarily ceased to flow from the boil.

The mere construction of a levee of full grade and section on a defective foundation does not give security and but little diminishes the action which takes place. White Oak Levee is almost a continuation of the Buckridge levee. Conditions here are somewhat different. The foundation is sand. Back of the levee is White Oak Lake. From the very start, this levee gave trouble. A banquette was built by local authorities during a yellow fever quarantine. The material used was muck from the lake bed. When the levee was enlarged to full grade and section, this banquette was disregarded and the whole work was done to the front. The completed levee therefore had two 40-ft. banquettes, giving a base 40 ft. wider than standard. The work was completed just before the high water of 1916 and had practically no effect. Sand-boils, some quiet and some spouting, appeared in the lake. Part of the rejected banquette sloughed off and a good stream of water poured through. One hundred feet back of the levee another stream spouted a regular fountain.

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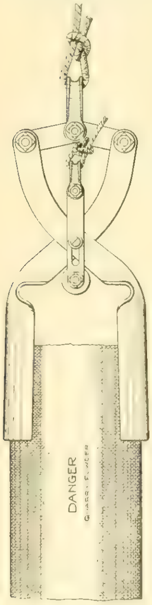
*From an article by Major W. G. Caples, U. S. Engineer, in the January-February Professional Memoirs.

The high water of 1916 showed that a levee of full grade and section on a good foundation will give no trouble and will afford complete protection against the floods that it is built to resist. The problem today is the foundation. A levee is nothing more nor less than an earthen reservoir wall. The same precautions that have to be taken with the foundations of reservoir walls of equal height will have to be taken with levee foundations. The conventional search-ditch can be relied upon in most situations, but around old lakes and other old beds of the river the engineer will do well to take careful borings if he expects to give his levee the required 25-year life.

DEVICE FOR LOWERING EXPLOSIVES INTO DEEP DRILL HOLES.

One of the hazards connected with blasting is that incurred by dropping dynamite cartridges into deep drill holes. To guard against the possibility that one or more sticks of dynamite might be exploded by the shock, the cartridges are sometimes lowered by small, strong cords and sometimes by long, thin rods, made in sections and joined by screw joints. The rods are hooped into loops attached to the cartridges and can be released by a little manipulation and drawn up again. A useful device for lowering cartridges, designed by Mr. George T. Chambers, Quarry Superintendent for Dolese & Shepard Co., Chicago, Ill., is described in the June Travelers Standard. In this arrangement the lowering cord is secured to a cross-bar, the ends of which are attached to the handles of a pair of tongs, as shown in the sketch. So long as there is a tension on the suspension cord the jaws of the tongs (which should be grooved) will remain closed and will hold the cartridge in place. When the dynamite reaches the bottom of the hole, the jaws of the tongs are separated, and the dynamite released, by pulling on the lower, auxiliary cord that is shown. It is advisable to make the entire device of wood, to avoid explosions from sparks due to the impact of the tongs against the sides of the hole, but if metal is used it should be copper.



Blasting Overburden at Bluestone Quarries.—An interesting method of blasting overburden is employed at certain bluestone quarries situated at high levels along the Lehigh River bluffs. The "top" is 35 to 50 ft. thick and consists mainly of shattered shale and bluestone. A well is excavated some distance back from the face and to the full depth of the stripping. In this well heavy charges of black blasting powder are placed, 1½ to 2 tons being commonly employed. The force of the explosion hurls great masses of the debris over the cliff face, thus disposing of much of the material without further handling. Other masses are so completely broken up that removal is easy.

THE $80,000,000 CONSTRUCTION PROGRAM OF THE NAVY DEPARTMENT.

The Navy Department now has under way a construction program involving an expenditure of about $80,000,000. The work, a large part of which is nearing completion, includes the improvement and extension of navy yards, training stations, aviation stations, submarine bases, the erection of immense storage warehouses for supplies and munitions, the construction of dry docks capable of accommodating the largest vessels, gun shops, including the erection at the naval gun factory of the largest gun shop of the kind in the world and the erection of hundreds of buildings for the various branches of the service.

This work is being done under the direction of the Bureau of Yards and Docks, of which Rear Admiral F. R. Harris is the chief, assisted by a corps of civil engineers of the Navy, a special staff corps trained in this work. Under them is a large force of trained civilian engineers, designers, inspectors, and experts.

The improvement program, according to the Official Bulletin, amounts to the practical rebuilding of some of the navy yards and stations. This undertaking, which is well under way and in some cases nearing completion, provides building ways, shops, tools, cranes, and all of the requisite appurtenances, destroyers, submarines, scout cruisers, gunboats, and auxiliaries. Besides this, by indirect supervision and assistance, the warship building facilities of the large private plants have been increased, in some cases such assistance extending to the enlargement of shops and an increase in producing facilities at some of the large electric, steel, and ordnance plants of the country.

Remodeling and enlargement of all the power plants at the stations are well in hand and in nearly all cases under contract, and arrangements made for carrying out the plans long ago perfected so as to "tie in" these various important Government plants with industrial sources of power in their vicinity.

The shipbuilding facilities under way contemplate provision for the construction of the largest warships ever built. This involves the provision of structural shops, machine shops, and foundries of the most modern type, some of them heretofore unprecedented in size. The machinery for these buildings is most unusual in character. The crane service is a large step in advance of anything heretofore contemplated. Traveling cranes having a capacity as high as 300 tons are being built, while fitting-out cranes with a capacity of nearly 400 tons are planned. The largest cranes of such character ever before built, and these for England and Germany, are only 300 tons.

Long before the break with Germany the Navy Department had taken steps looking to the practical rebuilding on a large scale through a period of years of three of the most important Atlantic coast navy yards and a natural expansion and development of the other yards and stations. The declaration of a state of war changed this condition and required that all this improvement, and more than had been originally planned, should be put under way and completed within the shortest possible time.

A building program of this magnitude, involving $80,000,000, is usually distributed over a term of years, but this construction is being carried out on an unprecedented scale; many of the camps, warehouse, etc., are already completed, others will be done in a few weeks, and most of the building that would ordinarily have taken three or four years will be finished within nine months.

Some idea of the construction work being done by the Navy Department can be gained by the mention of some of the many improvements now under way.

New York Navy Yard: About $5,000,000 being expended on new ways for building the largest ships, the largest storage warehouses in the country, doubling machine shops, erecting new structural shops and other shops and buildings.

Philadelphia, League Island: New dry dock, 1,000 ft. long, which will be able to accommodate the largest ships; two new ways for shipbuilding; new structural and machine shops, pattern shop, and the largest foundry on the Atlantic coast; barrack for Marine Corps and other auxiliary buildings. The total expenditure involved will be about $18,000,000.

Norfolk Navy Yard: Dry dock, 1,000 ft. long, capable of accommodating the largest ships; new structural and machine shops and foundry; water front and other improvements, including barracks and other buildings, involving a total expenditure of nearly $20,000,000.

Washington: Naval Gun Factory being expanded into one of the largest plants of the kind; total expenditures about $7,000,000. New gun shop being erected which will cost about $2,000,000.

Mare Island, Cal.: Navy yard being equipped to build the largest type of battleships; camp for 5,000 men being erected.

Puget Sound, Wash.: $3,000,000 being expended in facilities for building cruisers and various types of auxiliary vessels, erecting storehouses and other necessary buildings.

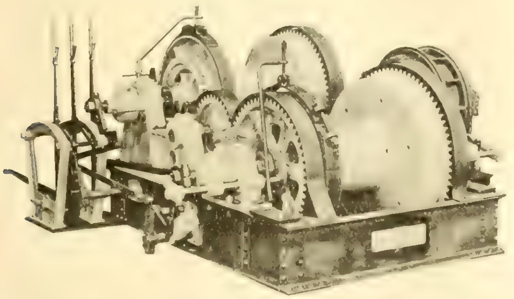
The Great Lakes Training Station, Chicago, is being expanded so that it will eventually provide for 20,000 men. A new aviation station has been constructed at Pensacola, Fla., with hangars, dirigible shed, launching sheds, and other necessary buildings.

The new camp at Port Royal, S. C., for the Marine Crops, accommodating 5,000 men, has been completed, as have also the barracks at Charleston, S. C., for 5,000 men. The new camp and training station at Quantico, Va., which will accommodate 10,000 marines, is well under way.

A TWO SPEED SLACK LINE CABLEWAY HOIST FOR DRAG BUCKET OPERATION.

An important development in hoisting machinery for scraper bucket operations brought out by the Lidgerwood Manufacturing Co., New York City, consists of an electrically operated two speed hoist for operating drag line excavators of the slack cableway type. The hoist is built in several sizes to operate buckets from 1 cu. yd. capacity to 2½ cu. yd. capacity. It is driven by an electric motor, the type of which is governed by the power conditions.

The hoist has two drums arranged tandem, these drums being driven through two gear reductions by the motor, which is located outboard to the drums. The forward or two speed drum carries the drag line which is connected to the digging bail of the bucket, the drum reeling the drag line at a speed of approximately 200 ft. per minute while filling the bucket and 600 ft. per minute for conveying the bucket along the main cable after the bucket has been loaded. The rear drum adjusts the tension of the main cable, and is a single speed drum geared for a maximum rope pull for tightening and loosening the main cable as required. The main cable is allowed to be slack while the bucket is filling and is tightened, thereby hoisting the loaded bucket after it has been filled, the two speed drum then conveying the loaded bucket to the dumping point at high speed.



Lidgerwood 2-Speed Slack Line Cableway Hoist.

The hoist is controlled by four levers in a quadrant located at the rear of the bedplate, there being one lever for the clutch, one for the brake of the rear drum, one lever to control the change speed device of the forward two speed drum, and one lever for the brake on the two speed drum. These levers are arranged conveniently to the motor controller which is generally of the drum type so that one man can easily operate the hoist continuously without unusual exertion.

The hoist is of very rugged construction throughout with structural steel bedplate and cut steel gears, the clutches and the brakes being lined with non-burn material and designed for the usual severe service that accompanies scraper bucket operations. Owing to the special type of clutches the application of the strains is very flexible and at the same time positive. The motor being located outboard or to one side prevents it being fouled by the particles of sand and gravel which usually adhere to the running lines and are brought into the hoist house in reeling in on the drums.

The hoists are equipped with motors ranging in size from 50 HP. to 150 HP. depending upon the capacity of the excavator and bucket which the hoist operates.

METHODS OF LEVEE LOCATION.

Under resolutions of the Mississippi River Commission each new levee built on the Mississippi River above New Orleans is located on a line which will give the levee a life of at least 25 years. The following notes on the methods employed by the government engineers in locating these new levees is taken from an article of Mr. W. E. Knoblach, assistant engineer, in the January-February Professional Memoirs:

In locating a new levee above New Orleans many things should be considered, viz: Its life, its cost, the value of property destroyed, the character of the foundation upon which it is built, and the material available for its construction.

The life of 25 years is determined:

(a) By taking a series of comparative bank lines at intervals of about a year. Thus the rate of caving is determined.

(b) By studying the caving to find out whether the rate of caving will increase or diminish. Care must be taken to ascertain whether the bank caves periodically or regularly. (Some banks cave periodically, at intervals sometimes as great as 5 years.)

(3) By observing changes in the bank for about 4 or 5 miles above the proposed new levee and observing what changes are occurring that might cause changes in the bank at the site of the proposed new levee. If the bank above is making out to the river and the making bank is working downstream, eventually the bank in front of the site of the proposed new levee will be either stationary or making.

After taking these observations, the future annual rate of the recession of the caving bank is estimated. The new levee line is then located so as to have its nearest point at a distance from the edge of the bank at least twenty-five times the rate of bank recession, plus a distance for a factor of safety. The margin for a factor of safety varies with the rate of caving or with the manner of caving. Where the bank caves regularly, the margin is 1¼ (for small levees) to 2 (in large levees) times the rate of recession; but, where the bank caves periodically, the margin is decided upon by the time of the last cave and the shape of the bank. If a cave has just occurred and a deep curve is in the bank, the same margin is used as in a case where the bank caves regularly; but, if the cave has not been recent and the bank has straightened out, instead of having curved pockets in it, at least three or four times the rate of caving must be added for the margin of safety.

After having decided where a levee can be located to give it the desired life, the other conditions are determined.

The cost is dependent upon the elevation of the ground upon which the levee is to be built, the facilities of construction, such as clearing base, draining borrow pits, and length of haul where teams are employed. Often the land next to the edge of the bank is low swamp and of very small value. In such a case, often, by going much farther back than the line of a 25-year life, a longer line can be built at a lower cost. Often the cubical contents, as well as the cost per cubic yard, are reduced.

In cases where a new levee could be built on a line farther removed from the edge of the bank than the line for 25 year life at much lower cost, the value of the property destroyed must be considered. Where the destroying of buildings, railroads, etc., is involved, not only must the value of the land be considered, but also the cost of removing and relocating of such structures must be considered. Where the difference in cost of the levee on a farther removed line over that of the line of 25 year life is less than the value of the property destroyed, the 25 year life line must be selected; but where the difference in cost is greater than the value of the property destroyed, the levee of the least cost is, as a matter of course, selected.

Two things are to be considered in the foundation:

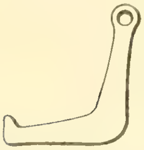
(a) Whether there is danger of a blow-out in the foundation during high water on account of a sandy foundation or on account of voids in the foundation caused by the decay of perishable matter. (This last condition sometimes exists in beds of old bayous which have been filled with a deposit of sand.)

(b) Whether the foundation can sustain the weight of the levee without great subsidence.

There is seldom much choice in the material available for the construction of a levee, and if the material is composed of not more than 60 per cent of pure sand, the material need not be considered in selecting the location. But if the material is all sand of recent deposit and, as often is the case in building a new levee where a crevasse has occurred, the cost of its removal and the cost of construction is not less than a levee located on a line where better material can be obtained, the location must be selected where suitable material can be procured.

The caving of a bank is not the only thing that necessitates the construction of a new levee, for, often, new levees are built where the existing levee is not up to the standard grade and section and is too close to the edge of a stationary bank to allow its enlargement, and frequently, existing levees which were constructed 30 or 40 years ago have given trouble in high water on account of the manner in which they were built. In these cases, new levees are built on a location which, in the first case, is far enough away from the edge of the bank to allow obtaining enough material for its construction, and, in the second case, is just back of the existing levee.

Grabhook for Hoisting in Quarries.—The accompanying sketch shows a form of grabhook used at a number of sandstone quarries in Ohio. The flat part between the tip and the bend of the hook presses firmly against the rock surface and relieves a large part of the pressure from the tip of the hook and from the corner of the block. The strain on the hook is less than when it is curved in the ordinary way, and also the block is held more securely. For hoisting heavy sandstone blocks one Ohio quarry company employs two pairs of grabhooks, one pair being attached near each end of the block.



CABLEWAY FERRY FOR SAND CARTS.

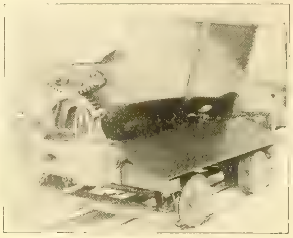
In the construction of the new filtration plant at Lowell, Mass., the contractor obtained the sand from a bank 1½ mile from the plant, but on the opposite side of a river. To avoid a haul of some 6 miles by way of the nearest bridge, the material was ingeniously ferried across on a scow, which carried two 2-horse carts. A light cable, slackly stretched across the river at about water level, served as a guide for grooved wheels, attached to the scow, and the necessary motive power was furnished by two men pulling with about the same motion as in rowing, on a wooden lever with a transverse slot at one end which fitted on the cable with sufficient clearance to permit the lever to be easily slid directly forward along the cable, but which gripped when the pull was applied at the end of the lever.

A NEW SMELTER CAR.

Unprecedented activity in the copper industry of the past two years necessitated the use of several types of new mine cars which are designed primarily for sustained heavy service.

A V-shaped type furnished for a large smelter by Orenstein-Arthur Koppel Co., Koppel, Pa., has rockers, pedestals and all cast parts made of heavy steel castings. The rockers are protected from falling material by heavy pressed steel guards.

Bumpers are of wood faced with steel plates and backed up by springs. The feature of the design is the chute plates which are fastened on the frame and help to carry the load out over the wheels when the body is dumped. This car has a gage of 4 ft. 8½ in. and a capacity of 50 cu. ft.



New V-Shaped Type Smelter Car.

Preventing Falls of Rock in Quarries.—Falls of rock or overburden are responsible for many accidents in quarrying. The greatest dangers from rock slides at the faces are in quarries where rock is produced for crushing purposes. The following precautions to prevent accidents of this kind are taken at a crushed-rock quarry near Pittston, Pa. The regular gang quits work at 4:30 p. m., and thereafter six reliable men roll down loose rock ready for the next day's work. Every fragment that appears to be in danger of rolling down is sent to the bottom. If during the day the process of removal disturbs other masses and renders them unsafe, men are sent to roll them down. One accident only, and that of a minor character, is said to have occurred in this quarry in the past three years.

PERSONALS.

John B. Wright has been appointed City Engineer of Attleboro, Mass.

George A. Duren, formerly City Engineer of Corsicana, Tex., has been appointed State Highway Engineer of Texas.

D. E. Colp of San Antonio, Tex., has been elected secretary of the Texas State Highway Commission with offices at Austin, Tex.

B. F. Affleck has been re-elected President and T. J. Hyman Secretary and Treasurer of the Universal Portland Cement Co.

Charles M. Upham, formerly chief engineer Du Pont Highway, has been appointed State Highway Engineer of Delaware. C. Douglas Buck, Wilmington, Del., succeeds Mr. Upham as Chief Engineer of the Du Pont Highway.

George C. Kenney has retired as president of the Beaver Contracting & Engineering Corp, Boston, Mass., to enter the U. S. Army, and Paul C. Ordway has retired as Secretary to enter the U. S. Navy. L. Gordon Glazier is now President and Secretary of the corporation.

Arthur M. Torrey, formerly with W. S. Barstow & Company, Inc., has left that organization to re-enter the employ of Hildreth & Co., Inspection Engineers, 15 Broad Street, New York City, with which firm he was connected for several years prior to joining the Barstow force.

At a recent meeting of directors of the Packard Electric Co., Warren, O., the following officers were named for the coming year: President, N. A. Wolcott; Vice President, Chas. Fillius; Secretary, R. E. Gorton Treasurer, N. A. Wolcott. Mr. Wolcott has been associated with the Packard organization in the position of Treasurer for the past 14 years. No immediate change in the company's policy is contemplated by the new officers.

W. G. Mackendrick, President Warren Bituminous Paving Co. of Toronto, Ont., operating under bitulithic paving patents of Warren Brothers Company of Boston, Massachusetts, who has been in France the past two years building roads at the front, has been given rank of Lieutenant Colonel with the same duties as before. Mr. Mackendrick first was Captain in Canadian Corps of Engineers, later a Deputy Assistant Director of Roads with charge of all roads in connection with the operation of the 5th British Army in France as Major. He now has 12,000 men operating under him and the splendid results on the repairing of roads, particularly during the German retreat, is largely due to his executive ability and long experience in road construction successively in connection with the several Warren Paving Companies, beginning with the Warren-Scharf Asphalt Paving Co. in about 1890.

Building and Structural Issue
of

Engineering and Contracting

Halbert P. Gillette, *President and Editor.* W. H. Fogerty, *General Manager.*

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HYSTERIA OVER RAILWAY TRANSPORTATION FACILITIES.

Talk "war needs" if you want to paralyze the reasoning faculty of the average man—yes, and of many men who regard themselves as far above the average in intelligence. To an engineer trained to use statistics, it is simply astounding to observe the degree to which so many men in political and semi-political positions have abandoned all rational use of "figures" and are "going it wild" in their exhortations to the rest of America. Thus the Special Coal Production Committee of the Illinois State Council of Defense has just recommended:

> Postponement, where possible, of public works and improvements that tie up open top cars necessary for the movement of coal.

The committee predicates this recommendation on the alleged fact that the coal mines of Illinois and Indiana will be required to produce 25,000,000 tons more coal during the coming year than during last year, as a result of the war. We seriously question the reliability of this estimate, but granting that it is correct, let us estimate the total number of cars required to handle this increment in coal production.

Dividing the 25,000,000 by 50 (the number of tons per car), and dividing this again by 365 (the days in a year), we find that less than 1,400 carloads would be the daily output. By prompt loading and unloading of the cars, each car can make the average round trip in a week. Hence 10,000 cars would be required for this additional service, which is less than half of one per cent of the total number of freight cars in America. While all freight cars are not adapted for use as coal cars, it is an exceedingly simple and inexpensive matter to convert old box cars into open-top cars. Instead, therefore, of recommending the curtailment of public works in Illinois in order to supply a mere 10,000 additional number of coal cars, the committee should have taken a broader view of the problem; and, had it done so, it would never have advised such a ridiculous procedure as the crippling of one form of industry for the purpose of aiding some other form.

This particular committee, it is true, includes railway officials, but it also includes coal dealers and operators. The former have clearly given no study to the broader aspects of this economic problem, while the latter have had only in mind their own narrow personal interests. Isn't it about time that committees of this kind were reorganized so as to include engineers who are accustomed to approach economic problems disinterestedly and with broad vision?

So long as such committees are made up entirely of those who have axes of their own to grind, we may look for a continuance of just the sort of recommendations above quoted.

Incidentally it may be added that the federal investigations of railway transportation problems have already led to the conclusion that there is a great abundance of railway rolling stock, provided it is properly handled. It has recently been said that by reducing the time that cars are held by shippers at both ends of the haul, there will result fully 20 per cent more car mileage per month. Only half the time of the average freight car is spent in traveling; the other half is spent at terminals and on sidings!

Let us bend our efforts toward getting greater mileage from freight cars, and cease these absurd and uneconomic recommendations that one branch of industry be throttled in order that some other branch may expand. There is room for an expansion during the war of all kinds of industrial, railway and government (local and national) works, if we but use our brains.

THE ECONOMIC HANDLING OF BUILDING MATERIALS WITH "GRAVITY ROLLERS."

Probably the steel mills were the first to use "roller conveyors" on a large scale for moving products considerable distances. The "rollers" were mounted on axles in a stationary frame, and were revolved mechanically, thus effecting the economic transportation of ingots, bars, plates, "shapes," etc.

Adopting this idea, but using gravity as the motive power, we believe it was Mathews who first used "gravity rollers" for handling brick. Paving bricks were thus transported from freight cars to wagons or trucks. Then, from stock piles along the street or road, the bricks traveled on gravity rollers to the men who placed them in the pavement.

The next development of the use of "gravity rollers" in the civil engineering field was for the handling of brick, tile, lumber and cement in constructing large buildings. Sections of these "gravity rollers" are jointed together, often forming a conveyor several hundred feet long. Such well-known engineering firms as the Ferro-Concrete Construction Co., of Cincinnati, are using "gravity rollers" extensively in their building work.

Consider, for a moment, the amount of labor that can be saved in transporting building materials by gravity instead of by wheel-barrows or the like. The materials, starting from an elevation, travel down a slight incline on the rollers, requiring neither labor nor power to move them. It is true that power is often needed to elevate the materials, but this is concentrated at one end of the conveyor and is relatively inexpensive. It is, in fact, analogous to the well-known method of "chuting concrete," except that concrete chutes must have a far steeper slope than that of a roller conveyor.

In our next Building and Structural Monthly issue we plan to give illustrations of the use of "gravity rollers" on building work, together with data as to the weights of these conveyors, the slopes at which they operate, how they are supported, etc.

A NEW THEORY OF HEAT CONDUCTIVITY.

Engineers who have studied published data relating to heat losses through windows, walls, pipes, etc., have long been puzzled by seemingly contradictory results. Moreover, there has been no satisfactory theory by the aid of which heat conductivity problems could be solved under a wide range of given conditions. Some years ago the editor of this journal began an investigation of the phenomena of heat transfer. Certain of the most important results of this investigation are given elsewhere in this issue.

The new theory of heat conduction involves a mathematical analysis of the effect of the presence of one or two "films" of gas or liquid adhering to the surface of the solid through which heat passes. The existence of such films has been known for many years and their retarding effect on heat transfer has been recognized, but no formulas have been available for use by engineers in calculating the quantity of heat conducted from a given gas or liquid at a given temperature through a given solid to a given gas or liquid at lower temperature.

While the formulas presented in this issue must eventually be supplemented by other formulas that will contain the factor of velocity of gas or liquid along or against the solid conductor, it will be evident that the formulas given in this issue are basic rational formulas of great utility. By their aid much that was hitherto obscure is clarified, and the engineer is no longer forced to rely almost entirely on empirical rules.

The "film theory" of heat conduction offers an escape from the empiricism which many authorities, like Prof. Lucke, had regarded as inescapable in solving many of the problems of heat transfer. It has been said that the variables were so numerous as to preclude the development of broad rational formulas for determining heat conductivity, but fortunately it has been found that most of the difficulty arose, first, from failure to recognize the existence of gas or liquid films adhering to solid conductors, and, afterward, from failure to give quantitative values to the thickness and heat resistivity of these films. If the article in this issue possessed no other merit than to direct the attention of engineers to the relative importance of the "film theory," its publication would be justified.

GOVERNMENT PRICE REGULATION OF PRODUCTS AND THE OPPORTUNITY FOR VALUATION ENGINEERS.

The first extensive experiment in the regulation of prices by the federal government was that carried on by the Interstate Commerce Commission. This, it is true, has affected only "the common carriers"—the railway, express, telegraph and telephone companies, but it has served to teach the public that a price-regulating power resides in the government. State public service commissions have also contributed to this form of public education.

The federal government is now about to regulate the prices of coal, foods, print paper, steel and copper, as a war expedient. How much farther this form of regulation may be carried it is difficult to predict, but it is obvious that as long as the war lasts there is to be a progressively expanding area of federal price regulation. As a result of this experience, may government regulation of many prices become a fixed habit? May we not be entering a new industrial era in which the old economic "law of supply and demand" shall more and more be regarded as an ineffective means of determining prices?

When combinations of producers and distributors have grown so powerful as to be able to determine prices, "the law of supply and demand" becomes largely if not entirely inoperative. Then the consumers, in self-protection, must either organize purchasing associations or appeal to the government to fix prices. This latter procedure has been adopted by several classes of producers, notably the publishers of newspapers and magazines, and it bids fair to become a common method of securing relief from what are regarded as burdensome prices. Once this practice becomes general, it may well be questioned whether the cessation of the war will bring an end to government regulation of prices of certain products hitherto regarded as not within the province of government control.

Should government regulation of the prices of products become general, it is evident that appraisal of manufacturing and mining plants and properties will be necessary. This will involve the services of valuation engineers. Moreover, many of these engineers will be employed in analyzing operating costs, depreciation charges and the like. In a word, there will come into existence many valuation staffs of engineers similar to the staff now appraising the railways under the direction of the I. C. C.

This leads us to suggest that many civil engineers may profitably extend their studies to embrace construction and operating costs relating to industrial plants—buildings, shops, mills, etc., etc. Many also should study corporation accounting and general economic principles.

A NOVEL "GAS-FILLED WINDOW."

The filling of incandescent lamp bulbs with nitrogen produced an astonishing increase in the illuminating efficiency of the electric lamp. A film of nitrogen about one-sixth of an inch thick adheres to the incandescent "wire" and is the cause of the increased brilliancy of the lamp. The "gas-filled lamp" has revolutionized the lighting industry.

In an article by Halbert P. Gillette, published elsewhere in this issue, it is shown that the heat resistance of window glass is so slight that if it were not for the films of quiescent air adhering to window panes, the heat losses from windows, great though they are, would be many fold greater. It is also shown that ordinary air has twice the heat conductivity of carbonic acid gas—the gas used in "soda water."

Mr. Gillette accordingly has designed a double window, the space between the panes being filled with carbonic acid gas or any other suitable gas having a low co-efficient of heat conductivity. With such a "gas-filled" window, the heat loss would be one-third what occurs with any ordinary single window when the air is still, and only one-fifth of what occurs on a windy day.

It would seem that in point of efficiency the "gas-filled window" is a good companion to the "gas-filled lamp."

CAN AN ECONOMIC FIREPROOF BARN BE BUILT?

At the last annual meeting of the American Society of Agricultural Engineers this question was put and answered affirmatively by W. G. Kaiser. Not only did he present a "paper design" of a cheap fireproof barn, but he showed photographs of an experimental section of such a barn, built by the Iowa Agricultural Experiment Station.

In the design of a barn the roof is the controlling factor. It must be of wide span and preferably of arched shape, giving free space for the traveling hay fork and the ready disposal of the hay. The experimental fireproof roof built in Iowa has a span of 36 ft. and a height of 25 ft. above the spring line. It consists of reinforced concrete ribs, 6 ft. apart, built in the shape of an inverted catenary. Between the ribs is a sheeting of hollow tile which is waterproofed. Tile was selected in order to secure a light roof and to reduce the amount of lumber for forms and arch centers.

In each concrete rib there is about 67 cu. ft. of concrete and 470 lb. of steel reinforcement. The rib is 10 in. wide, 8 in. deep at the crown and 14 in. at the springing line, and has a peripheral length of 65 ft. There are 450 tiles (5x8x12 in.) between each pair of ribs, forming a sheeting 5 in. thick. The roof is designed to withstand a wind load of 30 lb. per square foot. No. 6 wire is carried across the arch in every mortar joint between the tile. The concrete was not poured until the tile had been laid, and it was allowed to run into the air space in the tile, thus bonding the concrete rib to the tile sheeting.

This is a very interesting experiment, and one that Mr. Kaiser regards as being a demonstration of the possibility of building a light, strong and cheap fireproof roof for barns.

GOVERNMENT BRIDGE PIERS AT WASHINGTON TO BE BUILT BY DAY LABOR.

The lowest of five bids for piers and abutments for the Key bridge across the Potomac River at Washington, D. C., was $329,000, or nearly $100,000 above the engineer's estimate. Accordingly the bids were rejected by Col. William L. Fisk, Corps of Engineers, U. S. A. It is announced that the work will be done by day labor under the direction of government engineers.

We have had occasion several times recently to point out the increasing amounts of public works that are being built by day labor under the direction of engineers. Doubtless much more work will be done in this manner, for where contractors seem to be insuring themselves by high bidding prices against further rises in labor and material costs, it is only to be expected that engineers will advise the doing of work by day labor.

Again we suggest that engineers will do well to consider seriously the use of some form of cost plus a contingency fee contract rather than resort to the very risky day labor method. We call it risky because again and again has it happened that the anticipated saving of the contractor's profit has not only failed to materialize, but in its place has appeared a heavy deficit above the contractor's price.

A contingency fee contract may provide that if the labor cost of the work exceeds a specified sum, the contractor's fee of, say, 10 per cent, may be used to liquidate any such excess cost. This puts the contractor on his mettle to keep down the cost of labor, which is usually the item that varies most under different managers. Men working by the day for Uncle Sam are prone to take it easy in spite of the best efforts of the engineers who are in charge.

THE ECONOMY OF PLACING REINFORCING RODS AS "UNITS" OR "MATS."

In these days of labor scarcity there is more reason than ever for the handling and placing of structural materials in large "units" or composite groups rather than in small, separate parts. Thus, in handling steel bars for reinforced concrete floors, or the like, it will often be found wise to build the bars into "mats," each of which may cover more than 60 sq. ft. This was done, for example, in building the floor of the new municipal bridge over the Mississippi at St. Louis. The work was performed by day labor under the direction of Clinton H. Fisk, Chief Engineer of Construction.

On this work "mats" 4 ft. wide by nearly 16½ ft. long were made of 7 bars held together by light transverse pieces. The transverse pieces at each end of a "mat" were bars which were welded to the under sides of the 7 long bars. At two points between the ends there were spacers consisting of flat strips of steel in which lugs had been stamped out; the lugs were bent over the bars, holding them tightly in place. Two men carried and placed a "mat" with expedition and precision.

Although our present object is to emphasize the handling and placing of reinforcing metal in relatively large "units," we may be pardoned for again calling attention to the growing use of welded connections between the rods and the pieces that hold them together. Processes and tools for field use in welding have been remarkably developed within recent years but there are still many engineers and contractors who do not appreciate what can be done in the way of cheap and expeditious welding.

Temperature tests at 24° and 40° C. on 72 different species of wood-destroying fungi have been made recently at the U. S. Forest Products Laboratory. The lower temperature has proved to be the optimum temperature for 22 species, while at the higher temperature 54 of the forms have shown no growth in three weeks.

WHAT, WHY AND WHEN IS A SUB-CONTRACT?

To the Editor: General conditions of building specifications almost universally contain a clause providing that the contractor shall not sub-let any part of his work without the written approval of the architect. In view of recent events in the experience of the writer, the thought has occurred that the meaning of this familiar provision may be sufficiently open to question as to merit a free-for-all discussion in the pages of Engineering and Contracting.

The writer wishes to confess first-off that he has been prone to consider this clause as a dead letter, inasmuch as against him it has never been successfully enforced. It is evident, however, that many architects take it seriously, and every little while one arises to assert his duly specified rights and make an example of a presumptuous contractor.

Naturally consideration of this question should not ignore that other provision which forms an essential part of every contract and is generally an explicit part of every specification, to the effect that the original contractor shall be exclusively responsible for all material, labor and workmanship covered by his contract whether furnished and performed by him or by someone else.

In common parlance the term "sub-letting" is the converse of "sub-contracting" and refers exclusively to negotiations between a person holding a direct or original contract with an owner and a third party. The result of such negotiations can in no wise affect the legal relations of owner and original contractor, such relations presumably being accurately defined by the terms of the contract, which normally has for its object the accomplishment of certain specified work of value for the owner and not to ascertain how skilfully the contractor may manage to extricate himself from a mass of general and irresponsible restrictions written into the specifications by the cautious architect, and by means of which the latter may seek to impose his judgment over that of the contractor with respect to the management of the work for which the latter has assumed exclusively responsibility. Such being the case, what honest purpose can the provision have? Its real purpose in some specifications has been open to suspicion; but on what basis has it found its way into the new standard documents of the American Institute of Architects, whose officials are above suspicion?

The anticipated answer is that the owner must be protected against unskillful workmanship. Yet the architect, in approving a proposed sub-contractor, does not necessarily accord advance approval to his work, the original contractor still being held responsible in undiminished degree. Would such a sub-contractor in effect be answerable to the contractor or might he not deliberately ignore the contractor and his interests, assured by the architect of immunity from any financial penalty? May not the contractor justly question whether legally he could, on the one hand be forced under such a clause in the specifications to employ on the work only such persons as may be approved by the architect, regardless of the workmanship they may actually turn out; or, on the other hand, be held to answer for the behavior of persons over whom he is prevented by the terms of the specifications from exercising effective control?

It is the writer's opinion that both owner and contractor are allowing themselves to be bunkoed through this specification. There is neither law, custom nor trade necessity to excuse the letting of contracts to irresponsible or incompetent persons, nor is it evidence of business acumen to act on the assumption that an architect who cannot in the practice of his profession prepare plans and specifications intelligible to an experienced contractor, and by means of which the contractor may be held rigidly to the performance of certain work in a given way, is nevertheless qualified to direct and intervene without responsibility in the management and execution of construction work, which is the contractor's immediate specialty.

If it be desirable to exercise independent control over any portion of a structure it may always be segregated and let by direct contract with the owner, and the general contractor required by the terms of his contract to accommodate his work to such arrangement. The reason why such is not the usual practice doubtless lies in the abhorrence of architects for ultimate material responsibility and the supineness of contractors. It is time such practices were stopped and the technical press could perform a meritorious public service by repeatedly rubbing it in on lay and professional minds alike by precept and example—that authority must ever go hand-in-hand with responsibility in every walk of life if we are to enjoy peace and prosperity.

Apart from the main question just discussed, and taking conditions as they are, it is meet from a practical standpoint to recur to our opening question, and demand a clear definition of the term "sub-let" or "sub-contract." Although it may be customary to speak of buying rather than sub-letting lumber, mill work, hardware and steel, while we commonly speak of sub-letting plumbing, heating, roofing, masonry and plastering, an agreement to purchase in either case constitutes a contract. Moreover, what essential difference can it make to an owner whether the contractor pay the foreman in charge of a particular portion of the work by the day or week or a lump sum for the job?

The building industry is so highly specialized that many branches are most efficiently undertaken through the medium of specialty contractors. In some cases such procedure is rendered imperative by reason of the impracticability otherwise of obtaining the necessary materials, and, in certain cases, even the labor. The fact that the general contractor estimates the value of a given piece of work and undertakes for an owner to do the work for an agreed price, does not necessarily imply that he will do the work himself. But having thus obligated himself, is he to be limited by the whim of a third party as to the manner of his procedure?

Intimate knowledge of the economics of building construction is in general with the contractor rather than the architect, and every contractor could tell of many an owner that has been subjected to unnecessary expense because of an exclusive or ill-considered specification drawn, let us say, unwittingly, in the interest of a patented article of no special intrinsic merit. An instance is in mind of an asbestos-felt and composition roof at $15 per square placed on a reinforced concrete slab to underlie a layer of terra-cotta Spanish tile. The specifications were prepared through the friendly, gratuitous offices of a commercial specialist and competition was excluded. Of course the contractor has no cause for complaint under a definite specification as was the one in point, but if, under the wording of the general conditions, he may be limited in his procedure at the will of the architect, he has a very evident cause for complaint, and it is strongly to be questioned whether the position assumed by the architect is legally tenable.

Finally, let it be answered! What, why and when is a sub-contract? E. T. Thurston.

San Francisco, Cal.

PROPOSED NEW ARCHITECTS' LICENSE LAW OF CALIFORNIA.

To the Editor: In view of the movement in various parts of the country to control the practice of structural engineering and architecture by means of licenses imposed by political boards, I have thought your readers might be interested in the form which such a movement assumed in California before the Legislature recently adjourned. I, therefore, enclose a copy of Assembly Bill No. 1126 in the amended condition in which it finally emerged from the Assembly Committee on the Judiciary, together with an abstract of the same prepared for the convenience of a committee appointed by the San Francisco Association of Members of the American Society of Civil Engineers to oppose the passage of the measure.

The bill as proposed by the architects and as originally endorsed, provided that no buildings, except single-family dwellings, should be constructed in California unless designed, specified and superintended by a certificated architect, admitted all architects licensed under the existing law to a new license under the new law, and prohibited anyone from even taking the examination for a certificate unless he had for five consecutive years been in the employment of an architect.

The opposition of this Association to the measure was unconditional and based upon principles long since enunciated by the American Society of Civil Engineers, but the bill met with a variety of special opposition, such as of contractors or speculative builders of frame flats and apartment houses, agricultural, mining, lumbering, petroleum and public service interests, and the engineering and architectural schools and colleges, which discovered that their graduates would not be distinguished from office boys and others employed by architects with no preparatory training.

It was manifestly impossible to meet the objection of the engineers to submitting to the control of an architectural board in the practice of their profession without robbing the measure of its real purpose—which it will be recognized is not to provide for the public safety as stated in its title—but persistent attempts were made to meet other objections, thereby rendering the measure so ludicrous from the standpoint of public safety as to make it interesting reading. This will explain special exemptions noted in Section 5, the complete capitulation to the spirit of theoretical education in Section 6, the exemption of pretty nearly every interested party except future architects and engineers in Section 7, with special reference to the most objectionable of all, the speculative builder, and the exemption of all public work, Section 9. The bill was introduced and argued solely as a public safety measure, and, although evidence was overwhelming that architects almost invariably had to engage the assistance of practicing structural engineers to insure the safety of buildings of any importance, its proponents flatly refused even to consider a suggestion made by one of the Legislators that the examining board be constituted equally of structural engineers and architects.

It may be that the movement for regulation of private enterprise may ultimately extend in drastic measure to the engineering and architectural professions, but in the interest of the innocent public it should be made clear that safety in building construction cannot be insured by examining the designer and ignoring the design. It is the opinion of local engineers that a state building code provided with machinery to enforce it would constitute the simplest and most effective means of insuring safe construction. As a matter of fact, however, there was practically a total failure on the part of the proponents of the measure in question to adduce any evidence of unsafe construction in California. This is not to say that none exists, but that public life has not in general been noticeably in danger. At any rate there should be strong opposition among engineers to being licensed or in any way controlled in the practice of their profession by architects, who have yet to show themselves, as a class, noticeably competent in matters of safe construction.

Very truly yours,

E. T. Thurston,

Secretary-Treasurer San Francisco Association of Members of the American Society of Civil Engineers.

San Francisco, Cal.

[The abstract of the bill referred to by Mr. Thurston follows.—Editor.]

OUTLINE OF NEW ARCHITECTS' LICENSE LAW (A. B. 1126) ENTITLED

An Act Providing for Public Safety in Buildings within the State of California by Regulating the Construction, Alteration and Repair of Same, Providing for the Appointment of a Board to be known as the "State Board of Architecture," prescribing the Powers and Duties of Said Board, and to Provide Penalties for Violations of the Provisions Hereof.

Sec. 1. Provides for new State Board of Architecture of seven members composed of

4 certificated architects,
2 structural engineers,
1 teacher of structural engineering.

Sec. 2. Organization of Board, regular meetings in S. F. in April, in L. A. in October; Board shall adopt necessary rules; report annually to the governor, which report shall include financial statement, code of rules in force and a complete directory of holders of certificates; report to be printed and mailed to holders of certificates. The Board is empowered to employ "executive officers, deputies, attorneys, examiners, inspectors, clerks and other assistants as needed," fix their compensation, remove, demote and promote them and fix their duties, to rent, furnish and maintain necessary offices, and to enforce the act.

Sec. 3. Members of Board serve without compensation, but shall be reimbursed for necessary expenses incurred. Expenses to be paid out of fees collected; excess moneys over a working cash balance of $1,500 to be turned over to the State treasurer.

Sec. 4. Defines the term "structural engineer."

Sec. 5. Prohibits the construction or structural alteration of buildings unless "designed, specified and supervised or superintended" by a person certificated hereunder as "architect" or "to design and superintend the construction of buildings" and who has endorsed by his signature each of the drawings and specifications or reproductions thereof used in connection with such work.

The following classes of buildings are exempted from the provisions of the law:

(a) Buildings used in connection with farming, mining, logging, lumbering, petroleum works, electric or water power plants, water supply, irrigation or sewage disposal.

(b) All single-family dwellings.

(c) All buildings of not over two stories, not used for public assemblage.

(d) All frame buildings of not over three stories, not used for public assemblage.

Sec. 6. Applicant for examination must have had practical experience in designing or supervising buildings, 5 years for structural certificate, 6 years for architectural certificate; credit for college study is accorded as follows:

For one year's study—six months' practical experience.
For two years' study—one year's practical experience.
For three years' study—three years' practical experience.
For four years' study—five years' practical experience.

Fee for structural certificate, $50; fee for architectural certificate, $75.

Sec. 7. Examinations. The applicant for a certificate "to design and construct buildings" must pass examinations in the following:

(a) Structural engineering "to insure that the applicant has a solid theoretical understanding and a working knowledge of the principles and mathematics involved in the computing of all stresses and strains in the mechanics of building operations."

(b) Theory and practice of sanitation of buildings and ability to design plumbing systems.

(c) Theory and practice of heating and ventilating of buildings.
(d) Stereotomy.
(e) Practical electricity.
(f) Fire protection of buildings.
(g) Specification work.
(h) General education and knowledge of architectural forms.

An applicant for a certificate as "architect" must in addition be examined in the following:

(a) Elements of architecture.
(b) Architectural design.
(c) History of architecture.
(d) Free-hand drawing.
(e) History of ornament.
(f) Shades and shadows, and use of color.

Persons will be granted certificates without examination, as follows:

(a) Holders of certificates from another state or persons of 10 years' experience in places not requiring certificates, on payment of fee of $10, a certificate fee and current annual license fee.

(b) Structural engineers in independent practice, on payment of $5 certificate fee.

(c) Any persons submitting photographs and specifications or plans and specifications of one or more buildings in California, designed by him or by persons employed by him, and erected under his supervision, on payment of $5 certificate fee.

(d) Architects certified under the present law, on payment of $5 certificate fee (but the following paragraph provides for the perpetuity of the old certificates without extra charge).

Sec. 8. Annual license fee is fixed at $5 and causes and conditions of revocation are specified.

Sec. 9. Exempts public work from the provisions of the act by permitting regular public officials and employes as such to design and superintend buildings without certificate, but providing that all special employes in such connection must be holders of certificates under the act.

Sec. 10. Safeguards act against possible decision that portions are unconstitutional.

Sec. 11. Repeals the present law entitled "An Act to Regulate the Practice of Architecture."

Data on the effect of resin on durability worked up for 105 samples of longleaf pine at the U. S. Forest Products Laboratory, indicate that increasing amounts of resin tend to be directly correlated with increased durability. Individual blocks do not necessarily bear out this relation, showing that there are other factors involved.

THE GAS FILM THEORY IN RELATION TO HEAT CONDUCTION, AND A LARGE TABLE OF HEAT CONDUCTIVITIES.

By Halbert P. Gillette.

Principles.—That a film of quiescent air adheres to all solids has been long known to physicists, and for several years it has been recognized that such films have an effect on the transfer of heat from solids to gases or vice versa. For example, in Encyclopedia Britannica under Heat, Prof. H. L. Callendar says:

> The greater part of the resistance to the passage of heat [from the hot gases through a boiler plate to the water] resides in a comparatively quiescent film of gas close to the surface, through which film the heat has to pass mainly by conduction. * * * Some resistance to the passage of heat into a boiler is also due to the water film on the inside. But this is of less account, because the conductivity of water is much greater than that of air, and because the film is continually broken up by the formation of steam, which abstracts heat very rapidly.

This statement is loaded with practical importance, yet it contains a fact whose utility is as yet little appreciated by engineers.

In 1912 Irving Langmuir, an engineer of the General Electric Co., read two important papers in which he showed that the film of quiescent air adhering to incandescent wires is 0.17 in. thick when no wind is blowing. He also gave formulas for calculating the air film thickness at various temperatures and when subject to currents of air moving at different velocities. See his paper presented before the American Institute of Electrical Engineers, Vol. 31 (1912), p. 1011, etc., and his paper in the Physical Review, Vol. 34 (1912), p. 401.

The reading of the papers above mentioned led me to make some experiments to determine the film thickness of water. I ascertained that at low temperatures and in "still" water (i. e., water not mechanically stirred), the equivalent film thickness of water is about 0.05 in. Having ascertained this fact, I analyzed the tests that Peclet made in 1841 (see Annales de Chemie et de Physique, 1841, vol. 2, pp. 107 to 115), and I found that his hitherto discordant results were readily harmonized by the application of the film theory. I found that the equivalent water film thickness was about 0.007 in. in Peclet's tests where the water was agitated by paddles, and I was able to show exactly why and to what degree Peclet's conclusions as to the heat conductivities of metals were erroneous and why his conclusions as to other substances were substantially correct.

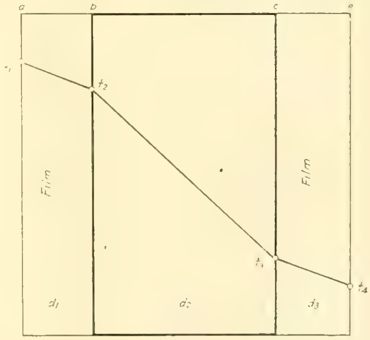


Fig. 1—Diagramatic Illustration of Film Theory.

Gratified by these results, I next undertook to determine the equivalent film thickness of steam, and I was able to do so for certain conditions, but I have not yet secured sufficient experimental data to deduce a formula for all conditions. Nevertheless I have established a very remarkable fact, namely that the equivalent film thickness of steam is far less than that of air, which, as I will indicate later, is a matter of far reaching importance.

Formulas.—In its simplest form, the film theory is graphically illustrated in Fig. 1, where a temperature

Table I.—Coefficients of Heat Conductivity (B. T. U. Per Squire Ft. Per Hour for Each Degree Difference in Temperature on the Opposite Faces of a Plate 1 In. Thick). These Coefficients Are for Low Temperatures.

	k
Mineral Solids—	
Brick, fine red (14)	4.1
Brickwork (11)	4.8
Firebrick (15)	3.2
Chalk (14)	5.8 to 9.6
Clay, tough sundried (14)	6.4
Clay, soft, very wet (14)	9.0
Carbon, gas (15)	24.7
Concrete, stone	6.4
Concrete, cinder (13)	2.3
Fluospar, rough crystal (14)	27.8
Galena, rough crystal (14)	20.3
Glass, soda (15)	5.0
Glass, crown (5)	7.0
Glass, flint (5)	5.8
Glass, quartz (18)	10.4
Glass (11)	6.6
Glass, plate (14)	6.1
Glass, German, toughened (14)	5.4
Granite (14)	15.4
Graphite, artificial, at 212° F. (24)	980.0
Ice (16)	16.5
Ice, at 14° Fahr. (17)	6.4
Ice (9)	6.7
Iceland spar, along axis (5)	29.0
Iceland spar, perpendicular to axis (5)	24.4
Iron pyrites (14)	29.0
Limestone, fine (11)	16.7
Limestone, ordinary (11)	13.7
Limestone, Caen stone (14)	12.5
Marble, fine grained (11)	28.0
Marble, coarse grained (11)	22.4
Marble, white (5)	20.6
Marble, miscellaneous (14)	14.5
Mica, perp. to cleavage (5)	5.2
Plaster, lime and sand (11)	3.9
Plaster of Paris, dry (12)	1.2
Plaster of Paris, dry plate (14)	3.5
Plaster of Paris, wet (14)	4.6
Porcelain (5)	6.9
Quartz, along axis (5)	87.0
Quartz, perp. to axis (5)	46.0
Quartz, opaque crystal, and quartzite (14)	25.0
Salt (solid) (5)	40.0
Salt, rock, rough crystal (14)	32.0
Sandstone (19)	31.0
Sandstone and hard grit, dry (14)	16.0
Sandstone and hard grit, wet (14)	17.4
Sandstone, calcareous, firestone (14)	6.1
Serpentine, red Cornwall (14)	12.8
Silica, fused (15)	6.9
Slate (5)	13.6
Slate, along cleavage (14)	17.4
Slate, across cleavage (14)	9.9
Sulphur (5)	1.3
Whinstone, trap rock, and mica schist (14)	8.1 to 13.9
Whinstone, trachyte, porphyritic (20)	17.1
Whinstone, trap rock (19)	12.2
Mineral Grains and Fibres (dry)—	
Asbestos paper, ordinary (5)	1.65
Asbestos, wound tight (12)	0.82
Asbestos, fine (12)	1.96
Asbestos, air-cell at 212° F. (25)	0.99
Asbestos, air-cell at 572° F.	1.45
Ashes, loose bituminous (12)	0.84
Ashes, loose anthracite (12)	1.08
Ashes, wood (11)	0.53
Brick dust, sifted (11)	1.33
Chalk, powdered (11)	0.87
Chalk, ground, Paris white (12)	0.82
Clay paste and vegetable fibre (12)	1.24
Coal, small, sifted (11)	0.55
Coal, anthracite powder (12)	1.43
Coke, pulverized (11)	1.29
Diatomit, at 212° F. (25)	0.81
Diatomit, at 932° F. (25)	1.33
Earth (see Soil and Sand below and see Clay above).	
Fossil meal, loose (12)	0.58
Fossil meal, packed (12)	0.63
Fossil meal, paste with hair (12)	0.67
Fossil meal, paste with asbestos (12)	0.88
Infusorial earth, natural, at 212° F. (25)	0.99
Infusorial earth, natural, at 572° F. (25)	1.16
Lamp black, loose (12)	0.39
Lamp black, packed (12)	0.42
Magnesia, loose, calcined (12)	0.50
Magnesia, packed, calcined (12)	1.70
Magnesia, light carbonate (12)	0.55
Magnesia, at 212° F. (25)	0.67
Magnesia, at 572° F. (25)	0.72
Mineral wool (see Slag wool).	
Pumice stone (14)	1.60
Sand (12)	2.48
Sand, white, dry (14)	2.70
Sand, white, saturated with water (14)	20.30
Slag wool, best (12)	0.52
Snow, compact layers (21)	1.48
Soil, dry (5)	0.97
Soil, wet (5)	4.64
Vitribestos, at 212° F. (25)	1.42
Vitribestos, at 932° F. (25)	2.90
Organic Solids (dry)—	
Boxwood (15)	1.04
Cork, (5)	0.38
Cork (11)	1.15
Cork, strips bound on (12)	0.58
Ebonite (5)	1.16
Fir, perp. to fibres (11)	0.75
Fir, parallel to fibres (11)	1.37
Leather, cow (5)	1.16
Mahogany, across fibres (5)	1.36
Mahogany (15)	1.48
Oak, perp. to fibres (11)	1.70
Oak (15)	1.68
Paraffin (5)	1.77
Paraffin at 32° F. (22)	0.67
Paraffin at 212° F. (22)	4.90
Pine, white, across grain ([illegible])	1.10
Rubber, pure Para (5)	1.10
Rubber, India (11)	1.37
Rubber, gutta percha (5)	1.33
Rubber, gutta percha (11)	1.38
Rubber, vulcanized, soft (14)	1 to 1.57
Shellac (5)	1.74
Vulcanite (14)	2.61
Walnut (5)	0.97
Walnut, perp. to fibres (11)	0.83
Walnut, parallel with fibres (11)	1.40
Whitewood (15)	1.68
Organic Fibres and Grains (dry)—	
Calico (11)	0.40
Cambric, varnished (7)	1.10
Canvas, hemp (11)	0.42
Charcoal, wood, powdered (11)	0.64
Charcoal, cork (12)	0.48
Charcoal, white pine (12)	0.56
Cotton (5)	1.59
Cotton batting, loose (2)	0.32
Cotton batting, tight (2)	0.20
Cotton wool, carded (12)	0.41
Cotton wool (11)	0.32
Eiderdown (11)	0.31
Eiderdown, very loose (2)	0.31
Eiderdown, slightly packed (2)	0.17
Eiderdown, tightly packed (2)	0.13
Feathers, geese (12)	0.38
Flannel (5)	0.67
Hair felt (12)	0.41
Linen tape, varnished and baked (7)	1.00
Paper, blotting (11)	0.27
Paper, writing (11)	0.35
Paper (5)	0.90
Paper (12)	0.56
Paper, blotting, wound tight (12)	0.82
Rubber tape (7)	3.00
Sawdust, mahogany (11)	0.53
Silk (5)	0.3 to 0.64
Strawboard (15)	0.97
Straw, chopped (11)	0.56
Straw, rope wound spirally (12)	0.72
Straw, loose rice chaff (12)	0.75
Wool, loose (12)	0.32
Wool wadding, loose (2)	0.34
Wool wadding, packed slightly (2)	0.25
Wool wadding, packed tight (2)	0.16
Wool wadding (11)	0.32
Metals—	
Aluminum at 64° F. (5)	1461
Aluminum at 64° F. (4)	1392
Aluminum at 212° F. (4)	1427
Antimony at 32° F. (1)	128
Bismuth at 64° F. (4)	56
Cadmium at 64° F. (4)	644
Copper, soft drawn, at 64° F. (5)	2657
Copper, commercial, at 64° F. (4)	2425
Copper, pure, at 64° F. (4)	2660
Copper, pure, at 212° F. (4)	2633
Gold (3)	1700
Gold (15)	2044
Iridium (15)	409
Iron, cast, 64° F. (4)	313
Iron, cast, 212° F. (4)	313
Iron, wrought, 64° F. (4)	418
Iron, wrought, 212° F. (4)	412
Lead, 64° F. (4)	241
Lead, 212° F. (4)	220
Magnesium (1)	1090
Mercury, 32° F. (22)	43
Mercury, 122° F. (22)	54
Molybdenum (15)	1003
Nickel (4)	412
Palladium (4)	487
Platinum, 64° F. (4)	483
Platinum, 212° F. (4)	502
Rhodium (15)	609
Silver (4)	2917
Steel (see below under alloys).	
Tantalum (15)	377
Tungsten (15)	1360
Tin, cast (5)	455
Zinc (4)	768
Metals, Alloys—	
Bismuth Alloys:	
Lipowitz alloy (50 Bi, 25 Pb, 14 Sn, 11 Cd) (5)	14
Copper Alloys:	
Brass (70 Cu, 30 Zn) (5)	754
Brass (2)	900
Brass, red (1)	813
Brass, yellow (1)	735
Constantin (60 Cu, 40 Ni) (4)	201
German silver (62 Cu, 15 Ni, 22 Zn) (5)	17
German silver (30% Ni) (2)	194
Manganin (84 Cu, 4 Ni, 12 Mn) (5)	15
Iron Alloys:	
Iron, 0.1% C. (5)	426
Cast iron (7)	277
Cast iron (3% C, 1% P, 1% Mn)	316
Steel, hard (8)	176
Steel, soft (8)	321
Steel "transformer" (2)	222
Steel, 1% C. (5)	334
Nickel Alloys:	
Nickel, 1% impurity (5)	409
Calorite (65% Ni, 15 Fe, 7 Mn) (2)	110
Platinum Alloys:	
10% Ir (4)	217
10% Rh (4)	205
Liquids (quiescent, at 54° F.)—	
Alcohols, amyl	0.95
Alcohols, ethyl	1.22
Alcohols, methyl	1.44
Benzol (22)	0.97
Carbon disulphide	0.99
Chloroform	0.84
Ether (22)	0.87
Glycerin (22)	2.03
Mercury (22)	44.00
Olive oil (22)	1.16
Petroleum (22)	1.03
Sulphuric acid (22)	2.23
Turpentine (22)	0.94
Water, at 39° F. (22)	4.00
Water, at 74° F. (22)	4.40
Water, at 68° F. (6)	4.15
Water, at 77° F. (5)	3.98
Water, at 117° F. (5)	3.48
Gases (quiescent)—	
Air, at 68° F. (7)	0.17
Air, at 212° F. (7)	0.21
Air, at 32° F. (26)	0.15
Ammonia at 32° F. (26)	0.13
Carbon bisulphide (CS_2) at 62° F. (27)	0.05
Carbon monoxide (CO) at 32° F. (26)	0.14

	k
Carbon dioxide (CO_2) at 32° F. (26)	0.09
Chlorine (27)	0.06
Hydrogen at 32° F. (26)	0.95
Marsh gas (CH_4) at 48° F. (26)	0.19
Nitrogen at 48° F. (26)	0.15
Nitrous oxide (N_2O) at 48° F. (26)	0.11
Oxygen at 48° F. (26)	0.16
Sulphuretted hydrogen (H_2S) (27)	0.10
Sulphurous acid (SO_2) (27)	0.06
Steam at 212° F. (27)	0.19
Water vapor at 32° F. (27)	0.15

Notes:
(1) Lorenz.
(2) Randolph.
(3) Wiedeman and Franz.
(4) Jaeger and Diesselhorst.
(5) Lees.
(6) Milner and Chattock.
(7) Langmuir.
(8) Kohlrausch.
(9) De la Rive.
(10) Berget.
(11) Peclet.
(12) Ordway.
(13) Norton.
(14) Herschel.
(15) Barratt.
(16) Neumann.
(17) Forbes.
(18) Eucken.
(19) Kelvin.
(20) Ayrton and Perry.
(21) Hjelstrom.
(22) Weber.
(23) Hutton-Blard.
(24) Hering.
(25) Skinner.
(26) Winkelmann
(27) Gillette (estimated k = cvs, in which c is a constant, v is viscosity and s is specific heat.)

See Smithsonian Physical Tables and Everett's C. G. S. System of Units.

gradient is shown from t_1 to t_4, through two gas or liquid films and a solid. Heat flows from a temperature t_1 through a film of thickness d_1, to a solid which it enters at a temperature t_2, dropping to t_3 after passing through a thickness d_2, and thence to a temperature t_4 after passing through a film of thickness d_3. Each film is supposed to conduct heat exactly as if it were a solid, so that the temperature gradient through the film is an inclined straight line. Let H be the number of heat units (B. T. U.) that pass through this system, in one hour. Let k_1 be the coefficient of heat conductivity of the first film; k_2 that of the solid; and k_3 that of the second film. Then

$$(1)\qquad H = k_1\frac{t_1 - t_2}{d_1} = k_2\frac{t_2 - t_3}{d_2} = k_3\frac{t_3 - t_4}{d_3}.$$

This is true because it has been established by experiment that the quantity of heat conducted in a given time varies directly as the drop in temperature and inversely as the thickness of the conductor. We are now confining our attention entirely to heat conduction, and are ignoring the heat radiated from the surface of a solid into space. Radiated heat losses are often of great importance, but I shall not attempt here to discuss this phase of the heat transfer problem.

From equation (1) it is evident that

$$(2)\qquad d_1 = k_1\frac{t_1 - t_2}{H}.$$

Equation (2) may be used to calculate the equivalent film thickness when the other factors are known. Usually, however, t_2 is not known directly as a result of test but must be calculated. But if we know H, d_2 and k_2, we may calculate $t_2 - t_3$ from the following:

$$(3)\qquad t_2 - t_3 = \frac{Hd_2}{k_2}.$$

Then deducting $t_2 - t_3$ from $t_1 - t_4$ we have the temperature drop in the two films; and if those films are of the same gas or liquid and if the temperature drop in each of them is the same as in the other, we can readily deduce the drop in each film.

Figure 1 is an ideally simple picture of heat conduction from a gas or liquid through a solid to a gas or liquid. It is apparent that the actual heat gradients through gases or liquids are not straight lines, as assumed in Fig. 1; but it seems wise to adhere to this simplified form of the theory, at least for the present. And to indicate that we recognize that there is curved heat gradient through the gas or liquid, let us use the term equivalent film thickness. By this we shall be understood to mean that whatever the temperature gradient and however complex the convection currents in the gas or liquid, their quantitative effect is the same as would occur were there a perfectly quiescent film of gas or liquid through which the entire temperature drop occurs. The thickness of this ideal film we may call the equivalent film thickness, and if calculated as above indicated it can be accurately used in Equation (1) for calculating heat transfer.

Table I gives the coefficients of heat conductivity of many solids, liquids and gases, expressed in B. T. U. per square foot per hour through a thickness of 1 in. when the temperature drop is 1° F.

Problem.—Ignoring the heat lost by radiation from the surface of a glass window, what amount of heat will pass per hour from a room whose temperature is 70° F. to quiescent air outside at a temperature of 50° F., through a plate of glass 1 ft. square and ⅛ in. thick?

From equation (1) we may derive the following:

$$(4)\qquad t_1 - t_2 = \frac{k_2\ d_1}{k_1\ d_2}(t_2 - t_3).$$

$$(5)\qquad t_3 - t_4 = \frac{k_2\ d_3}{k_3\ d_2}(t_2 - t_3).$$

But from the condition given in the question, we have

$$(6)\qquad (t_1 - t_2) + (t_2 - t_3) + (t_3 - t_4) = 70° - 50° = 20°.$$

Substituting (4) and (5) in equation (6) we get

$$(7)\qquad \frac{k_2}{k_1}\frac{d_1}{d_2}(t_2 - t_3) + (t_2 - t_3) + \frac{k_2}{k_3}\frac{d_3}{d_2}(t_2 - t_3) = 20.$$

$$(8)\qquad t_2 - t_3 = 20 \div \left(\frac{k_2}{k_1}\frac{d_1}{d_2} + \frac{k_2}{k_3}\frac{d_3}{d_2} + 1\right)$$

Since in this case both films are air, $k_1 = k_3$ and $d_1 = d_3$, whence

$$(9)\qquad t_2 - t_3 = 20 \div \left(2\frac{k_2\ d_1}{k_1\ d_2} + 1\right)$$

The film thickness of quiescent air, d_1, is 0.17 in.

Table I gives k_1 (air) = 0.17, and k_2 (glass) = 6.6, whence

$$(10)\qquad t_2 - t_3 = 20 \div \left(\frac{2 \times 6.6 \times 0.17}{0.17 \times 0.125} + 1\right) = 0.2°.$$

Hence the temperature drop through the glass is only 0.2°, leaving 19.8° as the drop through the two air films, or 9.9° through each film. This shows in a striking manner what resistance to heat transfer is offered by the air films as compared with glass an eighth of an inch thick. But it should be repeated again that conduction is only part of the entire problem, for radiation from the glass is no slight factor in heat transfer. Ignoring radiation and proceeding with the calculation of conduction by applying equation (1) we have

$$(11)\qquad H = k_2\frac{t_2 - t_3}{d_2} = \frac{6.6 \times 0.2}{0.125} = 11.56 \text{ B. T. U.}$$

Hence the loss through the glass windows is 11.56 B. T. U. per square foot per hour when there is a 20° drop between the air inside and outside, and making no allowance for the additional heat lost by radiation from the outer surface of the glass whose temperature is approximately 60°. This radiation loss is readily calculable, but need not be discussed in this article.

Conclusions.—We now see how very important a factor is the resistance of the equivalent air film in problems of this character. The thickness of the equivalent air film decreases rapidly when the air is mechanically agitated, as when a wind is blowing. Also powerful convection currents, such as occur when $t_1 - t_2$ or $t_3 - t_4$ (see Fig. 1) are great, reduce the thickness of the air film. For this reason a strong wind blowing against a window pane almost doubles the heat lost by conduction. Hence, also, double-windows or double glazing is so effective in reducing heat losses. In a double window there are four air films instead of two, and a strong wind can reduce the thickness of only one of the four.

Although an air film has an equivalent thickness of 0.17 in. when not disturbed by strong air currents, this thickness is decreased greatly when very powerful convection currents or winds are driving against extended areas of films. Experiments are needed to establish formulas for calculating film thicknesses when $t_1 - t_2$ or $t_3 - t_1$ varies, for it is evident that the greater the temperature drop the stronger the convection current and the less the equivalent film thickness. Also tests are needed to establish the effect of mechanical agitation of gases and liquids.

Steam Films.—In my analyses of all available experimental data on heat transfer, I was struck with the slight resistance offered by steam. I have been unable to find any tests giving directly the coefficient of heat conductivity of steam, but I have deduced its conductivity (which I give in Table I) by an application of a physical law which gives results probably within ten per cent of the truth. Steam, then, has a conductivity coefficient not greatly differing from air at the same temperature, but steam transfers heat many fold faster than does air, which, as I view it, is possible only because the equivalent film thickness of steam is much less than that of air. I also find that steam films decrease in thickness much more rapidly than air films as $(t_1 - t_2)$ increases. It seems to me that this fact gives us an explanation of some hitherto obscure phenomena, such, for example, as the fuel efficiency in the blast furnace due to the use of refrigerated or dry air. The absence of a steam film around the iron ore favors the retention of heat that enters the ore by radiation, and the resulting higher temperature favors more rapid and complete chemical reaction.

Water in the ash pit of a boiler has long been known to increase fuel efficiency under certain conditions. The reason now seems to me to be that the steam film greatly facilitates the transfer of heat through the boiler tubes to the water and steam film on the other side.

Design of Windows.—To reduce the loss of heat through windows it is desirable to use double windows, or double-glazed windows, for in this way four air films are secured in place of two. When a strong wind is blowing the thickness of the outer air film is reduced almost to the vanishing point, leaving one thick air film in a single window and three thick air films in a double window. The thickness of the glass is a negligible factor, as above shown. Obviously a triple-pane window would be more effective than a double-pane window, but ordinarily the cost of triple-pane windows would be prohibitive. Accordingly I have designed a double-pane window in which the space between the two panes is filled with a gas of low conductivity, like carbon dioxide, the panes being hermetically sealed, preferably by welding of the glass at the edges. Table I shows that carbon dioxide has about half the conductivity of air, hence my design of gas filled windows will offer nearly 50 per cent more resistance to heat conduction when no wind is blowing, and 70 per cent more when a strong wind is blowing, than is offered by the ordinary double-pane window. Remembering that even an ordinary double-pane window offers almost three times as great a resistance to heat conduction as a single-pane window when wind is blowing, it will be seen that my design of gas-filled window (using CO_2) offers five times as great resistance as single-pane window. In short, the heat losses from buildings, which occur mostly through window panes, can be greatly reduced at relatively slight expense. Other gas than carbon dioxide may prove even better.

Design of Heat Insulated Walls.—The design of walls for refrigerators of all kinds, and for heat-insulated sides of vessels or pipes, may be greatly improved by the intelligent application of the film theory. Heat insulators depend, for the most part, for their effectiveness on the air entrained in their pores or fibres, thus creating innumerable films of air. I have designed a heat insulator, in which the walls are hermetically sealed and the space between filled with granular or fibrous material and a gas of low conductivity, such as CO_2 or SO_2. Such a gas-filled insulator has more than double the heat resistance of an ordinary air-filled insulator of equal thickness.

I have designed a somewhat similar insulator in which the granular or fibrous material is replaced by several layers of thin sheets of cloth, paper, or other material, separated slightly from one another so as to provide spaces filled with gas of low conductivity.

The hermetical sealing not only permits the use of a gas of low conductivity but excludes moisture and preserves the material used for filling.

Summary.—The practical applications of the film theory of conduction are so numerous and important that it is certain that many radical changes in the design of engineering structures and machines will occur within the next few years as a result of this theory.

To the experimenter a splendid opportunity presents itself to extend our knowledge of heat transfer and to coordinate the data into formulas readily applicable. Prior to the advent of the film theory heat conduction data were chaotically confusing. These will soon be reduced to order as a result of better understanding of this theory. Already the writer has co-ordinated many data hitherto contradictory.

GOVERNMENT CANTONMENTS AND OUTLINE OF FORM OF CONTRACT FOR THEIR CONSTRUCTION.

Eight of the 16 cantonments to be erected for the new national army of over 600,000 men are now under contract. During the past week contracts were awarded for cantonments at Battle Creek, Mich.; Rockford, Ill., and Des Moines, Ia. The Battle Creek work was awarded to Porter Brothers, railroad contractors, of Spokane, Wash., who also have an office at Detroit, Mich. About 2,000 buildings will be erected, requiring a total of about 30,000M ft. of lumber. The contract calls for an expenditure of approximately $3,500,000. The Rockford cantonment will be constructed by the Bates & Rogers Construction Co., 37 W. Van Buren St., Chicago, Ill., and will require an expenditure of $3,000,000 to $5,000,000. Charles Weitz Sons, Des Moines, Ia., were awarded the contract for the cantonment at Des Moines. The five other contractors for cantonments are as follows: American Lake, Wash., Hurley-Mason Co., of Tacoma, Wash.; Ayer, Mass., F. T. Ley & Co., Springfield, Mass.; Wrightstown, N. J., Irwin & Leighton, Philadelphia, Pa.; Columbia, S. C., Hardaway Construction Co., Columbus, Ga.; Atlanta, Ga., Arthur Tufts Co., Atlanta, Ga.

The contracts for the construction of the cantonments have been awarded on a percentage basis. This form of contract has been adopted as an emergency measure because of the necessity of completing these military cities, each for a population of about 40,000 persons, at a very early date. The necessity of all possible speed and the importance of avoiding useless expenditure have been the main considerations. It has been impossible, under this policy, to wait until all the plans are finished, the work advertised, and a lump-sum contract made for each cantonment.

The Government's interests are safeguarded by a clause permitting its representatives to terminate the contract at will. As there are no restrictions in the agreement which are considered likely to hamper the contractor it is not expected that there will be any serious differences of opinion between the Government and any of the firms chosen for the work. The concerns undertaking the various items of construction are given every possible help and incentive to put themselves in the position of being trustees of the Government detailed to provide the best homes for the new troops which it is practicable to give in the time available for the work.

The most interesting features of the form of contract are those governing the financial relations between the Government and the contractor. The latter is to be paid his expenses and a percentage of their total amount, out of which he must meet his overhead costs. The contractor's profit will come in the difference between this percentage and overhead expenses. The maximum amount on any contract is fixed at $250,000.

The Government promises to reimburse the contractor on the following items for which he makes an outlay:

1. All labor, materials, and machinery necessary for the work. No departure from the standard rate of wages in the locality may be made without the consent of the Government's representatives.
2. All subcontracts.
3. Rental for construction equipment hired or owned by the contractor at rates fixed in detail on the contract. The rates may be judged from the daily rental of $5 permitted for the use of an automobile.
4. Transporting, setting up and dismantling such equipment.
5. Transportation of field forces engaged in the work.
6. Salaries of resident engineers, superintendents, timekeepers, foremen or other men in the contractor's field office.
7. Buildings, field office supplies, equipment, commissary department, and hospital expenses required during construction.
8. Insurance and bonding expenses, uninsured losses and expenses incidental to the work and approved by the Government's representatives.
9. Fees, deposits, royalties and similar necessary expenses.
10. Transportation, traveling and hotel expenses of contractor's employes actually incurred in the work.

The Government has endeavored to give the maximum amount of flexibility to the contract in order that all low rates accessible to the Government in the matter of materials and other items of expenditures may be utilized. For instance, the Government may pay any or all freight charges incurred in obtaining material and machinery; which would tend to reduce the amount on which it must pay a percentage to the contractor. Also, through this arrangement, advantage could be taken of the specially low rates which the Government obtains from land-grant railroads.

Freight charges on hauls over 500 miles must be especially approved in every case by the Government's representative. The title to all work in progress or completed is in the United States and all materials and machinery for which the contractor is to be paid, under clause 1 of the preceding classification of expenses, belong to the United States as soon as accepted in writing by its representative.

The contractor is to furnish a bond for $250,000. His profit and overhead expenses must come from an additional payment made by the Government and amounting to 6 per cent of his expenses as enumerated above in cases where the work costs over $3,500,000 and running up to 10 per cent if the total is under $100,000. The total amount of this percentage payment will in no case be allowed to run over $250,000, no matter how high the total cost of the work may be.

The value of any construction equipment furnished by the Government is not included as a part of the cost of the work when determining the contractor's percentage, nor any uninsured fire or liability losses which the Government may pay to him under clause 8, nor any payments by the Government for freight, nor any of his overhead expenses. The contract fixes his compensation on the cost of work done by subcontract at 5 per cent and on the reconstruction of damaged work not over 7 per cent.

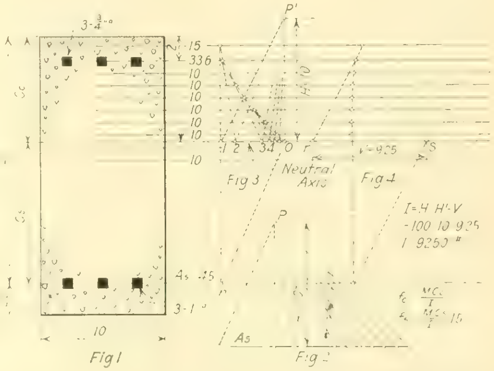
Provision is made for monthly payments for actual expenses approved by the Government's representatives who have access at all times to the accounts kept by the contractor. This puts the minimum strain on the contractor's financial resources while giving the Government a complete check on the accuracy and propriety of every item before payment is made on it.

THE GRAPHICAL DETERMINATION OF THE MOMENT OF INERTIA OF COMPLEX BEAM SECTIONS.

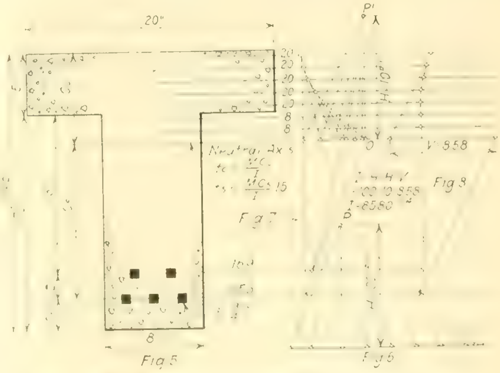
Contributed by W. S. Wolfe, Instructor in Architectural Engineering, University of Illinois

It is interesting to see how easy the moment of inertia of a complex beam section, can be found by graphical construction. Of course when it is obtained the common beam formula $f = \frac{M}{I}$ can be applied as illustrated by Mr. J. H. Cissel in the Engineering Record, vol. 75, page 457. That is $f_c = \frac{MC_c}{I}$ and $f_s = \frac{MC_s}{I} 15$.

Double Reinforced Concrete Beams.—Figure 1 shows the cross section of a double reinforced concrete beam (a double reinforced concrete beam has been taken because it is a little more complicated) the moment of inertia of which is desired. The compression side of the beam is divided into small slices, the area of the steel being multiplied by 15, and the areas of these slices are laid off in the force polygon, Fig. 2, together with A_s, equal to 15 times the area of the tension steel. For convenience the pole p is taken with the pole distance H equal to 100 sq. in. to the scale at which the areas were laid out in the force polygon. From Fig. 2 the funicular polygon, Fig 3, is drawn locating the neutral axis by the intersection 0. It will be noted that all the strings in this funicular polygon are extended until they intersect the neutral axis, the axis about which I is desired, at points 1, 2, 3, etc. Now for convenience the pole p′ is taken so that the pole distance H′ equals 10 in. to the scale at which the section of the beam was drawn, and p′ is connected with points 1, 2, 3, etc. Now, parallel to these rays the corresponding



Figs. 1-4—Diagram for Double Reinforced Concrete Beams.

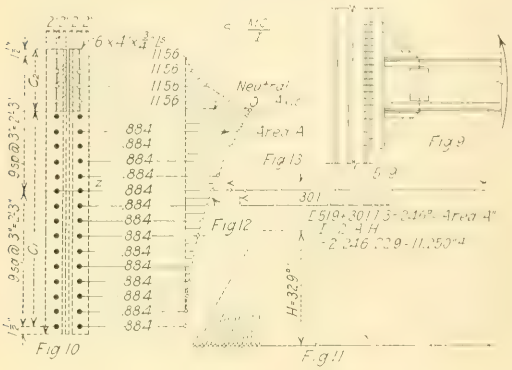


Figs. 5-8 Diagrams for Reinforced Concrete T-Beams.

strings in the funicular polygon, Fig. 4, are drawn, thus following Culmann's approximate method for finding the moment of inertia graphically. From this construction we get $I = H \times H' \times V = 100 \times 10 \times 9.25 = 9{,}250''^4$. From which f_c and f_s can easily be obtained for any given bending moment by using the formulas—

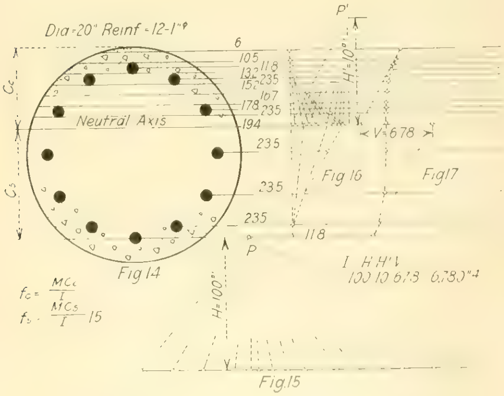
$$f_c = \frac{MC_c}{I} \text{ and } f_s = \frac{Mc_s}{I}\ 15.$$

Reinforced Concrete T-Beams.—Figure 5 shows the cross section of a reinforced concrete T-beam, the moment of inertia of which it is desired to find. The same general construction that was applied to the double reinforced concrete beam is used, that is, the force polygon Fig. 6 is drawn and from it the funicular polygon Fig 7, which locates the neutral axis. The pole p' is taken and the funicular polygon Fig. 8 is drawn which gives the intercept V. $I = H \times H' \times V = 100 \times 10 \times 858'' = 8{,}580''^4$. From which f_c and f_s may be determined as for the double reinforced beam.



Figs. 9-13—Diagrams for Girder Connection.

Girder Connection.—An interesting condition arises when we connect a wind bracing girder to a column by large connection angles, as shown in Fig. 9, in order to resist the bending moment which, at times, becomes large at the end of the girder. Suppose the bending moment is of such a nature as to produce compression at the top of the connection between the girder connection angles and the column, and tension at the bottom. Below the neutral axis where we have tension, the rivets are the stress taking element, but above the neutral axis where there is compression the stress is taken up, not by the rivets, but by bearing between the connection angles and the column. The first question which arises is regarding the location of the neutral axis. Below the line are all of the rivets in tension and above what line is there only compression? Before this question can be answered an assumption must be made as to how much of the angle legs in contact with the column are efficient in taking bearing. Let it be assumed that that part of the angles outside of the gage lines is not effective in taking bearing. The two compressive areas (see Fig. 10) each of which is therefore 2 in. wide, are for convenience divided into slices with a vertical dimension of 3 in. The effective area of each one of these slices is about 11.56 sq. in. The force polygon, Fig. 11, is drawn and from it the funicular polygon Fig. 12 which locates the neutral axis by the intersection 0. In this problem it is convenient to use Mohr's method of determining the moment of inertia, that is, $I = 2 \times A \times H$, in which H is the pole distance in Fig. 11, and A is the area enclosed by the funicular polygon of Fig. 12. This area is already divided into slices 3 in. wide by the lines from Fig. 10. The mean lengths of these slices are taken off by dividers and laid out on the lines in Fig. 13; the total length of these lines, times 3, gives the area A, and from the formula $I = 2 \times A \times H$, I is found to be 11,250 in.^{4}. The maximum rivet stress in pounds per square inch is given by $S = \dfrac{MC_1}{I}$ and the maximum compression between the angles and the column will of course be given when C_2 is used in place of C_1. The true section modulus is $\dfrac{I}{C_1}$ 11,250 ÷ 43 = 262''^{3}.



Figs. 14-17—Designs for Circular Reinforced Concrete Section.

Approximate Method in Error.—A common approximate method of determining the strength of the connection just considered is to assume that the section modulus of the rivets about the axis ZZ is a satisfactory section modulus. This section modulus has been computed for the connection under investigation and has been found to be 168 as compared with 262 from the graphical method, showing that the common approximate method of determining the strength of such a connection is very much in error on the safe side.

Circular Reinforced Concrete Section.—Figure 14 shows a circular reinforced concrete section. It would be a very difficult matter to find the moment of inertia of such a section about its neutral axis, when subjected to bending, by analytical methods; but when graphical construction is applied the solution is comparatively easy. The same construction that was used for the T-beam and for the double reinforced beam is used here, and I is found to be 6,780''^{4}.

AN ERECTION KINK FOR CRANE WORK.

Contributed by H. B. McDermid.

While erecting a number of large rotors for modern revolving field alternators, a big time saving stunt for hanging field poles came to the writer's notice. There were some 15 big rotors approximately 28 ft. in diameter to assemble, each carrying 52 pole pieces, weighing about 1,300 lb. each, and secured to the rotor-rim by 4 bolts. As the power house was served by two 150-ton cranes, the job looked simple enough. But it was found difficult to signal the crane man, or by any means to get rapid and accurate adjustment of the poles so that bolts could be entered in the tapped holes provided. The man with the right idea simply hung a 1-ton chain block on the crane hook, picked up the pole pieces with the chain block hook, and when hanging made the final accurate adjustment of vertical position right at the job with the block instead of crane. By this means he was able to do the work in from one-third to one-half the original time, and did it easier.

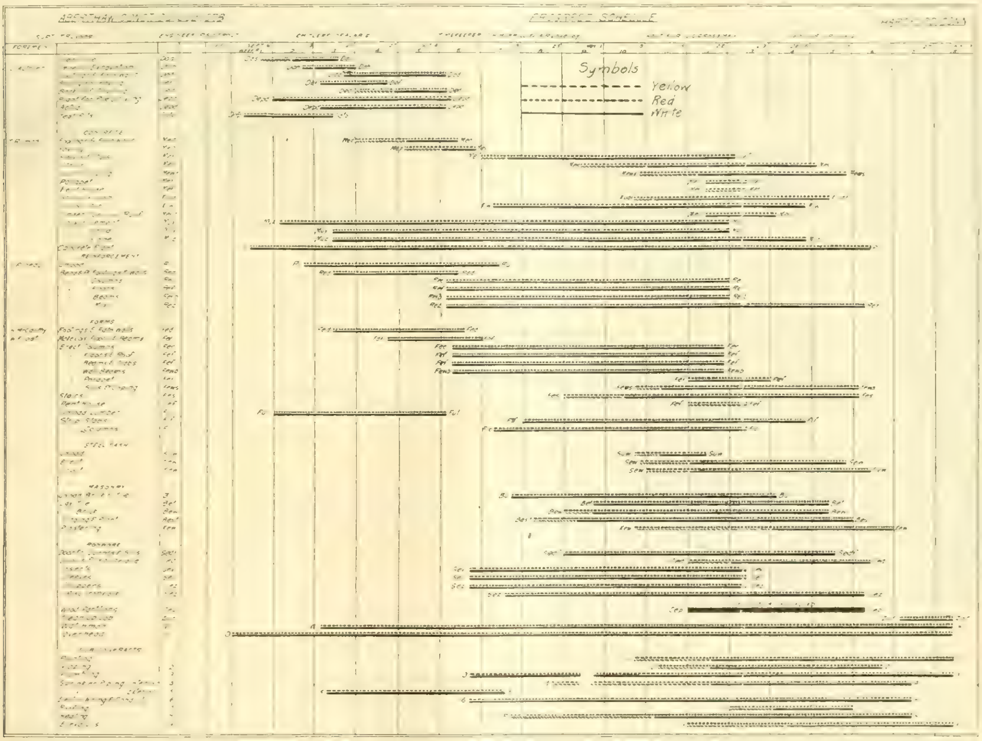
The trick is worth remembering, especially when a job must be accurately placed and is in a position where the hoisting engineer cannot see it, as signals passed through a line of men, or by means of whistles mean that correct adjustment becomes largely a matter of accident. With the chain block hung just above the load, the engine can be depended on for approximate placing, and the block quickly and easily provides the necessary accurate final adjustment for quick bolting up.

SCHEDULING PROGRESS OF A BIG CONSTRUCTION JOB.

A plan has long been sought whereby the number of men needed at each step in the construction work and the time of delivery of each item of material for the job can be definitely known before the job is started. In order to show what can be done along this line we reproduce below the progress chart used recently by the Aberthaw Construction Co. of Boston on the construction of a 5-story structure 490 ft. long by 60 ft. wide, with two wings approximately 60 ft. square.

As soon as the job was awarded this company made an estimate of the probable square foot of floor cost and began clearing the site. Meanwhile bids were secured on footings and pile foundations.

Coincidently, after a quick and thorough survey of local conditions, such as the available vacant land, the railroad siding and the probable streets along which materials could be delivered, and nearby sources of material that would be required, the engineering department made its first plant layout. Bins, sheds and office buildings were located and the place allotted for every class of material arriving on the job. This layout was subsequently perfected.



Progress Schedule Used by Aberthaw Construction Co. on Erection of 5-Story Reinforced Concrete Factory Building.

At the next weekly conference of the contractor's staff the entire job was taken up for discussion and definitely organized. At this conference were present the man who secured the contract, the general superintendent, the chief engineer, the purchasing agent, and the schedule engineer. A building superintendent was selected, together with his principal assistants, the carpenter, labor and planning foreman, engineer, and the master mechanic.

The discussion covered plant layout, including number and location of mixers, method of distributing the concrete, purchase and handling of lumber for forms, requirements in the way of steel and cement, prices and deliveries of these materials, architects' drawings, tentative progress schedule, and many minor questions. When each man left the conference he had a definite idea of the part he was to play in the new work.

As a basis for all operations the schedule engineer immediately perfected his progress schedule. Between the reports of the schedule engineer and the chief engineer the architects were constantly kept informed as to the dates upon which drawings must be in hand, while the requirements in the way of form lumber, steel, cement, etc., were furnished to the purchasing agent. The latter's responsibility ended when he had placed an order subject to specific deliveries. The job superintendent, being informed of the conditions of these orders, thereafter assumed responsibility for the direct following up of the required materials. All cases that he could not handle were referred back to the traffic department of the main office. In the case of sub-contractors who were manufacturers schedules were furnished and close touch was kept with the dates of beginning work and shipping finished products ordered.

On this particular job the situation was complicated by the New England freight embargo, but by having some source of supply always held in reserve serious delays were avoided. Plant equipment, small tools and stationery were requisitioned by the building superintendent upon a very complete blank furnished for that purpose. This blank covers everything required in the way of "plant" from hand saws to vertical engines, of small tools from anvils to wrenches, and of stationery from pay envelopes to rubber stamps. It is the business of the "yard" to keep its stock complete in each of the items so that shipment may be made without delay.

Following the requirements of the plant layout, offices and storehouses were shipped from the contractor's yard, each building being of standard sections 15 ft. wide in 10-ft. lengths.

As soon as the cement schedule was made out the order was placed, the storehouse was filled in advance of requirements, continuous shipments from the cement mill were maintained, and arrangements made with a local dealer so that his supply could be drawn upon in case of emergency.

All scheduled form lumber cut to dimensions was turned out by a local mill, delivered by truck to the job and piled separately, according to size, and ready for use.

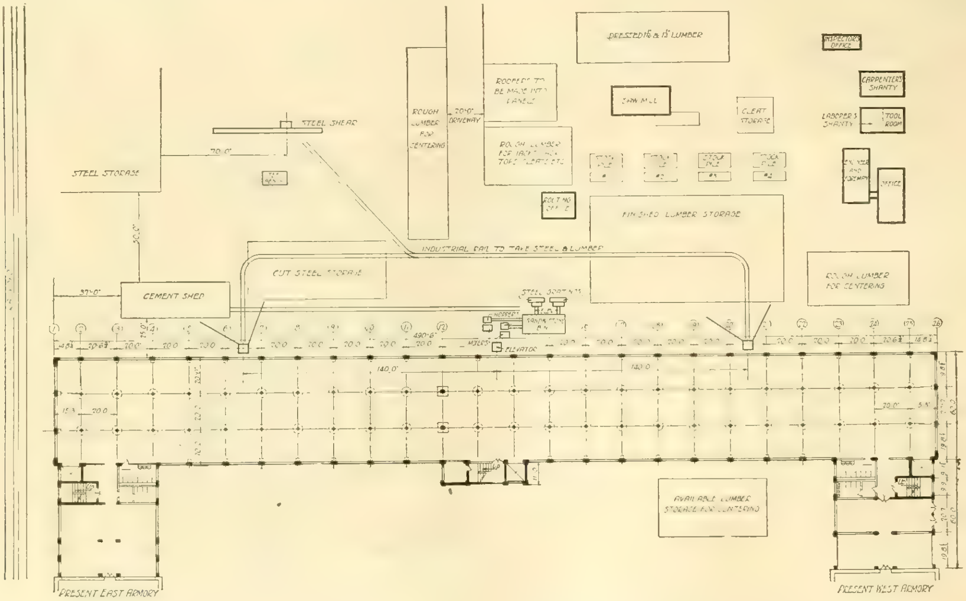
The progress chart, which graphically represents the dates and limits, and serves as a basis for recording progress, is reproduced herewith. Three blueprints of it are sent to the job—one for the superintendent, one for the routing clerk, and a third to be brought up to date weekly and sent to the Boston office. Another copy is kept on the board in the Boston office and is brought up to date weekly from the copy sent in by the job.

On the blank blueprint each item of work is represented by a wide white line. When the work is started it is recorded on the sheet by drawing a yellow line over the upper part of the heavy horizontal line. The length of the yellow line is made proportional to the amount of work done on that item, the entire heavy line representing volume rather than time, although it spans the period between the scheduled beginning and ending. It is, therefore, evident that the ratio of the length of yellow line to the total length of the heavy line represents the proportion of that particular item of work which has been completed.

When the work does not start on time a red line is drawn over the lower half of the wide line, and is continued to the date when the work stops. Then the yellow line is begun in its proper place. The red line therefore shows at a glance just how far behind the work is upon a given item.

Each week a piece of string is stretched vertically across the chart from the current date shown at the top of the sheet. If at any time the yellow lines extend beyond the string it indicates that the job is ahead of schedule on that particular item.

Thus the progress of the entire job is visually shown from day to day on the bulletin board in the home office.



Plant Layout of Aberthaw Construction Co. on Erection of 5-Story Reinforced Concrete Factory Building.

At the commencement of the University of Illinois on June 13, 1917, 210 Bachelor of Science degrees were granted to students of the College of Engineering, distributed as follows:

Architecture	26
Architectural Engineering	31
Ceramic Engineering	8
Civil Engineering	37
Electrical Engineering	43
Mechanical Engineering	40
Mining Engineering	7

THE EFFECT OF SEA WATER ON SOME OF THE CONCRETE STRUCTURES IN THE PHILIPPINE ISLANDS.

Contributed by J. L. Harrison, Scribner, Neb.

Some months ago the writer's attention was called to an article on a proposed harbor improvement in southern California, and more especially to a statement therein made to the effect that "Where concrete sea walls have apparently suffered from the action of the sea water between high and low tide the damage has been due not to chemical disintegration of the concrete by the action of the salt water, but to the saturation of the concrete surface, with alternative freezing and thawing of the contained water, the resultant contraction and expansion of which mechanically destroys the face of the wall. Needless to say, this trouble will not be encountered in southern California."

This was really a very surprising statement, for it is a well-known fact that concrete slowly disintegrates in salt water in cool climates, and it is also well known that at ordinary temperatures the addition of heat hastens chemical action. It therefore seemed highly improbable that this statement could be checked, but on the chance that it might be correct in spite of its apparent confliction with these two well-known facts an effort was made to ascertain its accuracy by examining a number of the concrete structures which stand in the warm waters of the Philippine Islands. A brief record of the structures which were examined and from which samples were taken for analysis, together with notations on the physical and chemical condition of the mortar above and below the reach of salt water, follows. The record is uniformly bad and should definitely settle the question as to whether concrete is a permanent form of construction when placed in warm sea water.

Forbes Bridge.—This is a 5-span bridge located in the city of Iloilo, P. I. It spans a tidal stream—one of the old mouths of the Jaro river. This stream now carries so little fresh water that the structure may be said to stand in ordinary sea water.

The Forbes bridge was built in 1909. The concrete work seems to have been pretty good. The sand used was a fine silicious sand, a little too fine in fact, and not properly graded, so the concrete is not as dense as it might have been, but on the whole the structure would pass as an ordinarily good piece of work. A 1:2:4 mixture was used in the part of the structure from which the samples were secured, and the surface was finished with a wooden float, some mortar having evidently been used to cover up form marks.

Samples were taken on April 18, 1916—one sample from the north abutment above the reach of high tide and a second from a point about 5 ft. lower down on the same abutment and between high and low tides. After drying for three days the mortar in the second sample had turned white and would break between the fingers like fairly hard chalk. The other sample remained normal in every respect. The two samples were submitted to the Philippine Bureau of Science for the determination of the calcium and magnesium content, and the bureau's report shows:

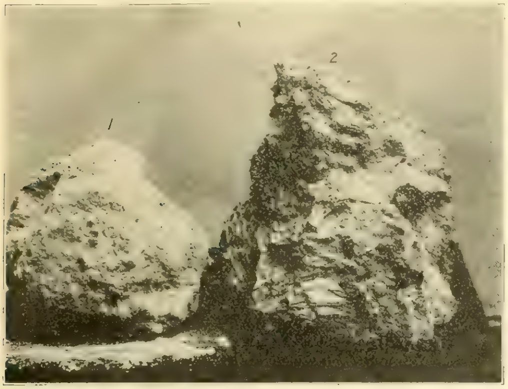


Fig. 1—Concrete from Batag Landing Pier. Sample 1 Has Entirely Lost Its Strength. Sample 2 Is Sound and Strong. The Particles in Front of Sample 1 Were Rubbed Off in Handling.

Sample 1—CaO, 21.01%; MgO, 1.52%.
Sample 2—CaO, 12.51%; MgO, 2.05%.

The other elements were not determined, but the loss in CaO and the increase in MgO are sufficient to explain the fact that the mortar in Sample 2 had very little strength.

Beacon Footings, Romblon Harbor.—These beacons were built some years ago (probably about 1905, but exact date not known), and the mix used is not a matter of record. The footings are simply blocks of concrete cast in place at the ends of a number of coral reefs which jut out into this harbor. The surface of these blocks was not finished in any way. Samples were taken from two footings at points about a foot above low tide. The mortar was of a peculiar consistency, and cut more or less like cheese. Chemical analysis showed 5.9 per cent of MgO in the mortar from one footing and 4.96 per cent in the mortar from the second footing. The analyst made no report on the CaO content. No samples from above high tide were taken.

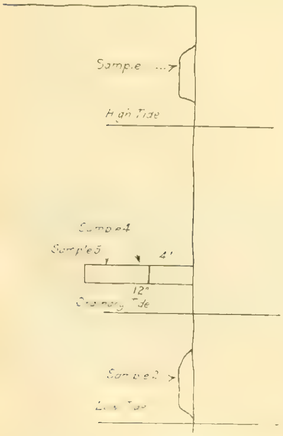


Fig. 2—Sketch Showing Location of Samples 1 to 5 on Iloilo RiverWall.

not known), and the mix used is not a matter of record. The footings are simply blocks of concrete cast in place at the ends of a number of coral reefs which jut out into this harbor. The surface of these blocks was not finished in any way. Samples were taken from two footings at points about a foot above low tide. The mortar was of a peculiar consistency, and cut more or less like cheese. Chemical analysis showed 5.9 per cent of MgO in the mortar from one footing and 4.96 per cent in the mortar from the second footing. The analyst made no report on the CaO content. No samples from above high tide were taken.

Batag Landing Pier.—This pier, or rather the remnants of it, is located in a small harbor in Batag Island, just north of the island of Samar. It was erected in the year 1906 to facilitate the landing of materials for the construction of a lighthouse on Batag Island, and was consequently viewed as a more or less temporary piece of construction. An examination of the remnants of the wharf leads to the conclusion that the mix must have been about 1:3:6. Coral beach sand and broken coral were used for aggregate. Salt water was used in gauging the concrete, much of which was apparently placed by tremie. It would appear that the work done was good. Only the footings and the columns of this structure were of concrete. The deck was of wood.

Much of the pier has completely disappeared. There remain, however, a number of the footings and columns, but the parts of them which have been subjected to the action of sea water hardly even resemble concrete. In fact both the cement and the aggregate have so far deteriorated that one can pull large pieces of the disintegrated concrete from the corners of the columns with his bare hands. That any of this soft material is left is probably due to the fact that no disturbance is caused on this harbor except by severe storms, and then only when they blow from one direction. Samples were taken both from just above low tide and from above the reach of high tide. The concrete from above high tide is sound in every respect and appears to be as strong as could be expected, considering the aggregate used. The concrete from just above low tide when wet cuts like cheese. When it is dry it crumbles in the hands more easily than soft chalk. In fact it is impossible to handle the dry samples without constantly breaking off small pieces. The Philippine Bureau of Science reports the following from a partial chemical examination of the mortar:

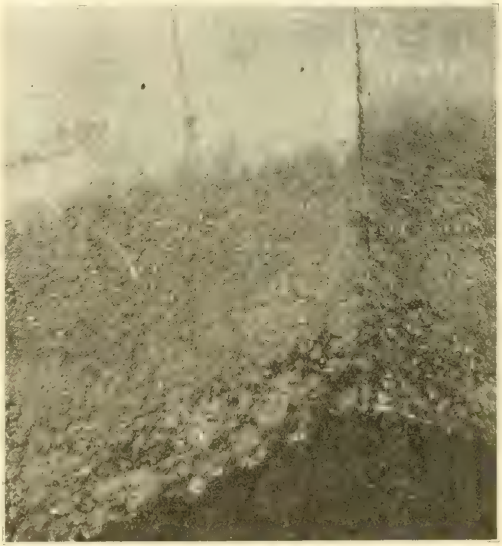


Fig. 3—View of Iloilo River Wall Taken at About Low Tide. Sample 2 Was Taken from Such a Place as This.

Sample 1 (above high tide)—MgO, [illegible]; CaO, [illegible]; $A_{12}O_3$, [illegible]; [illegible]

Sample 2 (just above low tide)—MgO, 11.42%; CaO, 32.96%; $A_{12}O_3$, [illegible]

The coarse aggregate (average of 2 analyses) showed SiO_2, 0.20%; $A_{12}O_3$, 0.36%; CaO, 54.34% MgO, 0.57%.

As the sand was of the same material as the aggregate its important elements can be judged from the partial analysis of the coarse aggregate.

Negros Bridges.—During the years 1908 and 1909 a number of small arch bridges were erected in the province of Occidental Negros. A number of these structures span tidal streams and are therefore subject to the action of water which is quite salty during the larger part of the year. The concrete used in these structures is said to have been a 1:3:6 mixture. River gravel, beach or river sand and sea water were used in the concrete. Some of the mortar is a little porous. Other structures show a dense mixture. The work as a whole seems to have been above the average.

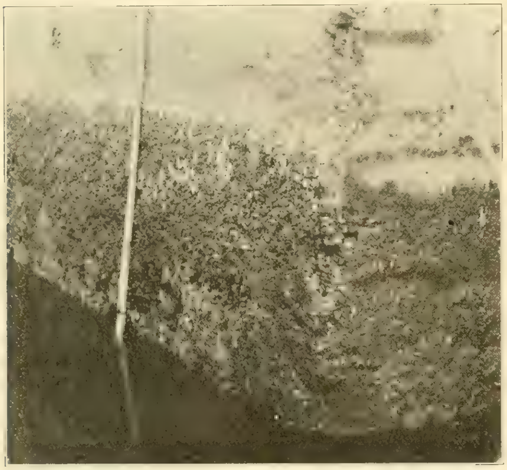


Fig. 4—Iloilo River Wall. The Deterioration Here Has Gone so Far That a Hole Over 4 In. Deep Has Been Formed. The Corner Also Is Badly Eroded.

Four or five of these bridges have been examined. In all cases where the tide strikes every day the mortar at the surface is soft, and in many places there are large areas where the original surface has completely disappeared, leaving a surface composed of coarse aggregate set in mortar, a surface somewhat like that of trass rubble. The mortar between the pieces of coarse aggregate, as where the aggregate is not yet exposed, is often so soft that a knife cuts it easily. Moreover, there is very little bond between the mortar and the aggregate. When dry the mortar may be so chalky that it crumbles easily between the fingers, and if a little of it chances to cling to a piece of coarse aggregate it can usually be removed by rubbing it in the hands.

These structures are so similar that samples for chemical analysis were taken from only one of them, the Mandalayan bridge. The Philippine Bureau of Science reports as follows in regard to the samples submitted:

Sample 1—From above high tide: CaO, 21.15%; MgO, 0.87%.
Sample 2—From just above low tide: CaO, 11.36%; MgO, 2.75%.
Sample 3—From a hole cut into the abutment at just above low tide; sample taken 4 in. below face of abutment: CaO, 16.70%; MgO, 0.76%.

The River Wall, Iloilo (Gravity Section).—The Iloilo River wall, located near the mouth of the Iloilo River (see also Forbes bridge), is a part of the improvement of this river for the assistance of the shipping interests. The section examined is a heavy gravity retaining wall and quay built some 7 or 8 years ago. A 1:2½:5 mixture was used. The wall was finished with a mortar facing and is said to have been placed in a very dry cofferdam from low tide up. The concrete is a little porous, as a poorly graded sand was used, but in other respects the work seems to have been first class. The aggregates vary somewhat, but most of the fine aggregate used was a silicious river sand and the coarse aggregate appears to have been largely river gravel, though some broken limestone was evidently used.

For 3 or 4 ft. above low tide the wall is covered by a growth of some kind of shellfish which probably protects the concrete from erosion to a considerable extent, but in spite of this there are considerable areas where the mortar coat has disappeared and where the coarse aggregate forms the greater part of the surface. Samples taken from these areas show that the mortar is almost totally devoid of strength and it seems likely that if it was not for the shellfish growth the surface erosion on this wall would be much greater than it is, for boats small and large are constantly coming and going, and beside the wave action that they produce there must be frequent collisions with the wall itself. Of course the wall is protected to some extent by a heavy sill buffer, but this is too high up to protect the wall from being raked by the small sail boats which frequent the river. A number of samples were taken for chemical analysis.

Sample 1, from above the reach of the tide.

Sample 2, from the surface of the wall at a badly eroded spot just above low tide.

Sample 3, from the surface of the wall where not eroded and about a foot above ordinary low tide.

Sample 4, from 4 in. below the surface of the wall, just under Sample 3.

Sample 5, from 12 in. below the surface of the wall and under Samples 3 and 4.

The Bureau of Science's chemical examination of these samples shows as follows:

	CaO.	MgO.
Sample 1	*	0.72%
Sample 2	10.67%	1.10%
Sample 3	21.32%	2.35%
Sample 4	22.43%	3.10%
Sample 5	22.66%	3.37%

*Not reported, as evidently out of harmony with other quantities reported.

N. B.—The accuracy of the determination of the MgO in samples 4 and 5 looks doubtful.

Commenting on Sample 2 the Bureau of Science report notes the following interesting facts, which are based on the assumption that the samples submitted were correctly proportioned and were from a 1:2½:5 mixture in which a sand free from calcium and magnesium elements had been used:

Calcium oxide in the mortar	10.67%
Which represents:	
Calcium oxide content for the cement alone	38.10%
Magnesium oxide in the mortar	4.10%
Which represents:	
Magnesium oxide content for the cement alone	14.64%
Excess of magnesium oxide (assuming 1.80% in original cement)	12.84%

It is not at all hard to understand why mortar which has suffered such extensive chemical changes as are shown by the above report has lost its strength.

Tanalo Bridge.—The Tanalo bridge is a highway bridge located near the town of Hinigaran, in Occidental Negros Province. It spans a tidal stream, and both the piers and abutments stand in practically pure sea water. It is a slab and girder bridge of standard Bureau of Public Works design, on standard piers and abutments. A 1:3:6 mix, composed of cement, river gravel, river sand and sea water, was probably used in the portion of the abutment from which samples were taken. The structure was begun in 1909 and completed in 1910. The work done on the whole structure was poor. The concrete is porous and in general poorly placed. The samples taken from below low tide and from between high and low tide showed the same deterioration noted in the mortar from other structures. The following samples were submitted to the Bureau of Science for chemical analysis:

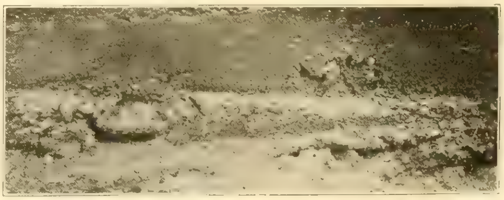


Fig. 5—Part of South Abutment of Orton Bridge, Built About 1908. High Tide Comes About to Top of Section Shown. The Knife Shown in Center of Picture Is Sticking About ¾ In. into the Rotten Mortar.

Sample 1—Taken from abutment above high tide.

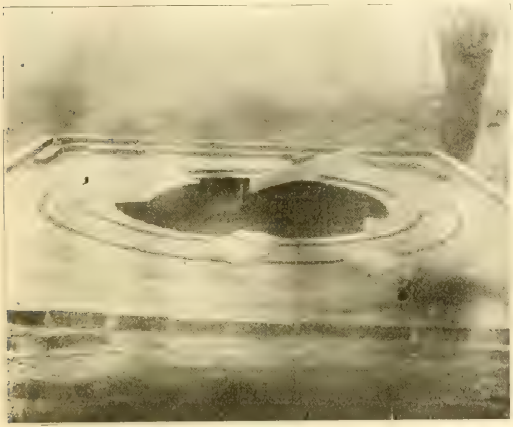
Sample 2—Taken from same abutment about 2 ft. above low tide.

Sample 3—Taken from pier 5 or 6 ft. below low tide, near base of pier.

	MgO.	CaO.	Al_2O_3.	SO_3.
Sample 1	1.54%	20.20%	5.92%	0.43%
Sample 2	2.58%	16.50%	6.12%	0.93%
Sample 3	4.13%	15.80%	7.72%	0.97%

TEST OF A FLAT CONCRETE TILE DOME REINFORCED CIRCUMFERENTIALLY.*

The test was made on a dome-shaped structure which in plan formed a panel 10 ft. wide and 12 ft. long between the interior surfaces of the supporting walls. The structure consisted of a thin shell made of concrete tiles 2¼ in. thick supported on concrete walls 8 in. thick and the entire structure leveled up by means of a 1:3:8 mix of cinder concrete 2 in. thick at the center and increasing to 6 in. at the ends. The average thickness of the cinder concrete fill was about 4½ in. The concrete shell was reinforced by means of circumferential rods ⅜ in. in diameter spaced 9 in. on centers.



View of Partially Completed Dome.

The concrete shell formed a portion of a hollow sphere 100 ft. in diameter. Thus any vertical section passing through the center of the dome formed the arc of a circle of 100 ft. diameter. This gave a rise of 3 in. between the inner surface of the wall and the center of the dome on the 10-ft. span and of 4.1 in. on the 12-ft. span. The shell was built of tiles made from a mortar of 1 part of cement to 2 parts of sand. They were laid in a mortar made up of 1 part cement, 1 part of lime and 6 parts of sand. They were laid in concentric circular courses, beginning at the corners and working toward the center without the aid of forms. The corners were filled in with partial courses until a complete circular course could be laid. Each tile dove-tailed into a tile of the previous course in such a way as to support the individual tiles by cantilever action until the course was completed.

The true spherical form of the dome was maintained by the use of a template which consisted of an arm cut to conform to the arc of a true circle whose diameter coincided with the vertical axis of the dome and whose radius was 50 ft. As this arc rotated about the vertical axis an arc of a true spherical dome was generated. By laying the tiles to conform to the position indicated by this template a spherical dome was secured.

Each course formed a zone which, after completion, was reinfored with a circular rod of ⅜-in. round steel placed in the circumferential groove formed by the notches cast in the tiles. Mortar similar to that above described was slushed into the groove around the reinforcement to give a bearing to the reinforcement. After a course was completed it depended no longer upon cantilever action in the tile for support.

The dome tested with static load at somewhat less than 30 days after erection. The load consisted of pig-iron, which was placed in increments of 2,000 lb. (16⅔ lb. per sq. ft.) until a load of 8,000 lb. had been reached and in increments of 4,000 lb. from then until the maximum load of 16,000 lb. had been reached. Observations taken during this vertical load test were (a) strain gage readings at gage lines shown in Fig. 1; (b) deflection readings taken at the center and at the deflection points shown in Fig. 1; and (c) outward deflection of the walls at the centers of the four sides. The latter measurement was to determine whether the walls were called upon to resist thrust.

After the load of 133 lb. per sq. ft. (total load 16,000 lb.) had been applied the entire load was removed. After another series of no-load readings had been taken loads of 38 and 100 lb. per sq. ft. were applied to the north half and strain gage readings were taken after each load to determine the effect of the eccentric load.

After the static load tests had been complete an impact test was made by dropping a stone various distances and observing the effect on the structure.

After the dome had been removed a determination was made of the ability of the walls to resist thrust by applying to them known horizontal loads and measuring the amount of horizontal deflection of the wall under these loads.

Fig. 2, 3 and 4 show the observed deflections under static load. At the maximum load of 16,000 lb. only one deflection reading, that at deflection point D, was taken. At this load some of the stresses had gone beyond the yield point and it was considered unsafe to go under the structure for the purpose of getting the complete set of readings. The lever arm deflection apparatus could be read from the outside, however, and this indicated a deflection of about 0.65 in. After the load had been in place long enough to make it appear that danger was not imminent a more accurate deflection reading (that on point D) was ventured. This showed 0.7 in. deflection. Fig. 2 shows the load-deflection curve for point D. This, as well as the strain gage readings, shows that at the last load the dome had yielded. It will be noted in Fig. 3 which gives deflections on a cross-section of the dome 15 in. south of the center that the central portion of the dome went down nearly uniformly, that is, at all stages of the test a line through points representing the deflections at E. D, and C would be nearly straight, indicating that the cracks which appear in Fig. 1 allowed the portion of the dome between these cracks to settle integrally throwing the main support out toward the corners of the supporting walls. There are some other indications of the same action in some of the strain gage data, but there is rather too much uncertainty about these indications to place much reliance upon them. Immediately after the removal of the load, deflection

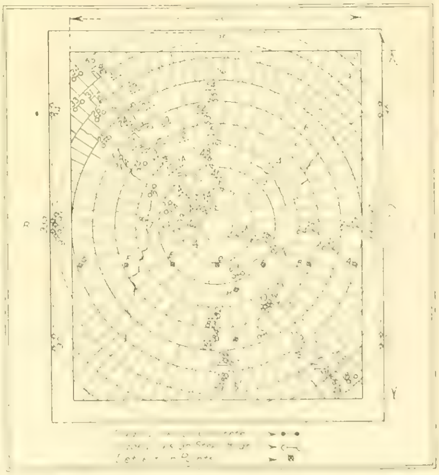


Fig. 1—Plan Showing Location of Gauge Lines, Deflection Points and Cracks.

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*Abstract of a paper prepared by Prof. W. A. Slater, University of Illinois, and C. R. Clark, for the last annual convention of the American Concrete Institute.

readings were taken and these showed a recovery of 27 per cent of the maximum deflections under full load. After standing 11 days without load another 6 per cent recovery had taken place, giving in all 33 per cent recovery. In order to see what effect an eccentric static load would have on the structure a load of 6,000 lb. was uniformly distributed over the north half of the dome and readings of deflection and deformation were taken. As shown in Fig. 3 by the dotted line the effect was only slight. In Fig. 4 deflections on a north-south section, 8 in. from the north-south center line are plotted and these indicate that the eccentric load did not change the shape of the north-south section more than that of the east-west section. The effect of the eccentric load seems to have been well distributed and not more marked than that of the same amount of load distributed uniformly over the entire area in the first application of load.

Fig. 5 to 9 show the unit-deformations computed from the readings taken with the strain gage. As explained in connection with the deflection readings it was considered unsafe to remain under the dome when the 16,000 lb. load was in place and consequently at this load strain gage readings were obtained on only those points which were accessible from outside the structure.

Fig. 5 gives the distribution of the unit-deformations found in a circumferential direction in the reinforcement. At the low loads the deformations were small, and the distribution of deformation is somewhat erratic. At the 12,000 lb. load the deformations were beginning to increase more rapidly and Fig. 6, which shows the average unit-deformation for the various rings, indicates compression in the central portion of the dome in a circumferential direction changing progressively into tension in the outer portion. This distribution curve indicates a point of zero stress about 30 to 33 in. from the center. It is statically necessary that the sum of the tensions occurring circumferentially across a radial section normal to a side of the structure is equal to the sum of the compressions across the same radius. It is apparent, however, that in this figure the area between the compression curve and the axis is greater than the area between the compression curve and the axis. It is evident that in order to obtain the total stresses there should be added to the areas here shown the areas corresponding to whatever stresses were carried by the concrete in compression and in tension. In compression the concrete would be fully effective and a considerable area would be added to the compression area shown in the figure which gives only the steel stresses. In tension the concrete was cracked and it may be that very little should be added to the outer or tension area. The effectiveness of the concrete in compression and its ineffectiveness in tension may account for the inequality between the tension area and the compression area as shown.

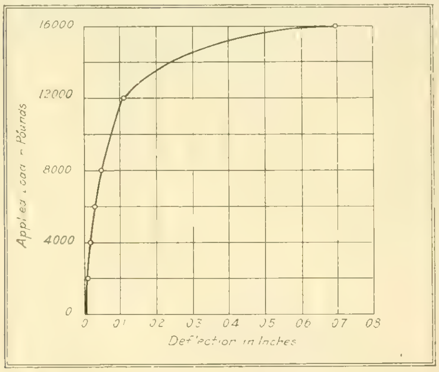


Fig. 2—Vertical Deflection at Point D Under Static Load.

Figure 7 shows the deformations measured circumferentially in the concrete on the under surface of the shell of the dome. There is so much irregularity in these curves that little can be made from them. This may be due partly to temperature variations within the structure, partly to different deformations across mortar joints from the deformations at other points, and partly to changes caused by the formation of cracks as the test proceeded. It is known that there was a considerable amount of variation of temperature within the enclosure of the structure due to artificial heat at time of taking observations. This heat could not be distributed with entire uniformity and it would affect the surface of the concrete much more than it would the steel which was embedded rather deeply in the concrete. That there was, at least in some cases, a difference between deformations in gage lines which crossed joints from those which did not cross joints may be seen from a comparison of gage line 23 (Fig. 9) with gage line 24 (Fig. 7). These gage lines are located in similar positions and close together, yet they show very large differences in deformation. The largeness of the deformation which may be found generally in circumferential gage lines which cross joints in the tension region helps to confirm the suggestion previously made that the concrete in tension was not fully effective, and that there probably was some separation of tiles at mortar joints even where no cracks could be detected.

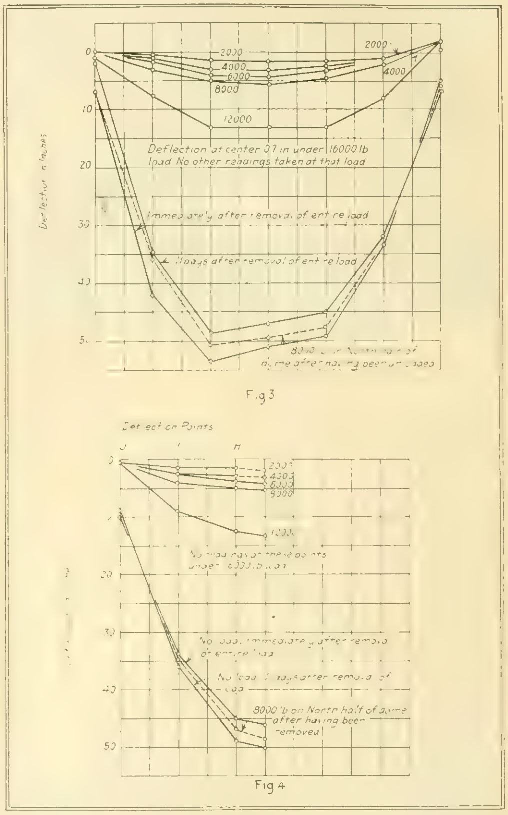


Fig. 3—Vertical Deflection on East-West Cross Section for Various Loads. Fig. 4—Deflection on North-South Cross Section for Various Loads.

The measured radial deformations are shown in Fig. 8. These were all measured on concrete and the same sources of difficulty in interpretation are present as in the case of circumferential deformations measured on the concrete surface except that since compression in a radial direction should be expected generally, the effect of the joints should be less marked.

With the thin shell as the only structural support and with no radial reinforcement, danger of sudden failure and of peculiar susceptibility to impact was considered. As a preliminary test a 50-lb. weight was dropped from a height of about 6½ ft. about a dozen times at the center of the dome, where the thickness of the cinder concrete fill was only 2 in. This caused a slight vibration of the structure, but had no permanent effect. Accordingly a more severe impact test was devised. A stone weighing 195 lb. (about 10 in. wide and 27 in. long) was raised varying distances and dropped on the dome. A derrick was improvised for raising the stone to the desired height. The hook with which the stone was attached to the block and tackle used in this apparatus was provided with a trip so that the stone could be suddenly released and allowed to fall entirely free from all restraint. The first seven blows were applied at the center of the dome, where the thickness of the cinder concrete fill was 2 in.

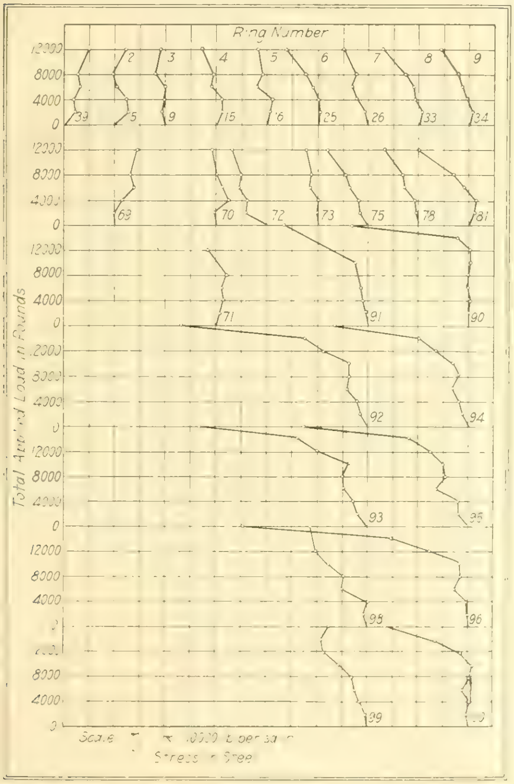


Fig. 5—Load-Deformation Diagrams for Circumferential Gauge Lines on Reinforcement.

In order to approximate the conditions under which such a structure would have to meet service tests 1-in. boards were at first laid on the top of the dome to receive the force of the blow.

It was soon ascertained that the effect was slight enough that in order to produce appreciable permanent effects the boards would need to be removed and they were not used after the application of the first two blows. To determine the effect of each blow a multiplying lever apparatus was used to determine the deflection at the center at the instant of impact. Due to the energy imparted to the pointer by the impact, the indicated deflection may have been greater than the actual deflection, but it does not seem likely that it could have been less. The heights of the drop varied from 4 ft. to 6 ft. 8 in. The data of the test are given in Table I. It will be seen that no puncturing of the surface took place until the seventh blow. The hole caused at this time was roughly oval with axes of about 13 and 15 in. respectively.

The first failure, as indicated in remarks in Table I, caused a rupture around the keystone of the dome, as shown in Fig. 10, and a shearing (or tension) along a portion of the first course of tile outside the keystone. The position of the latter surface of failure indicates

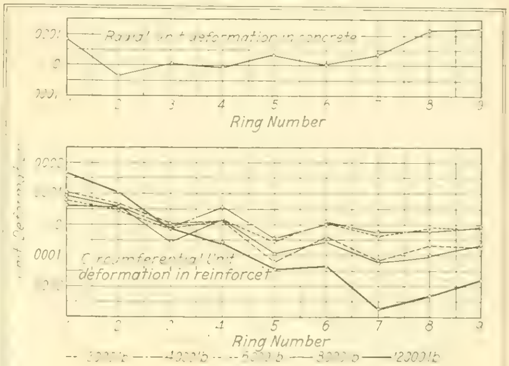


Fig. 6

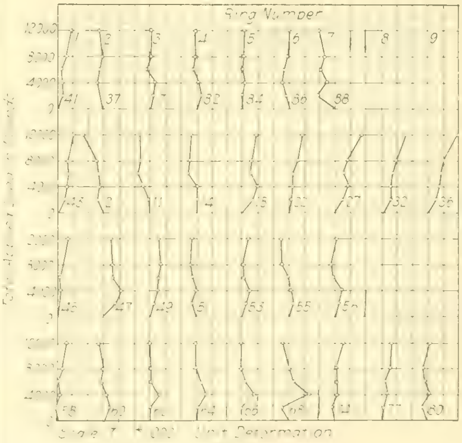


Fig. 7

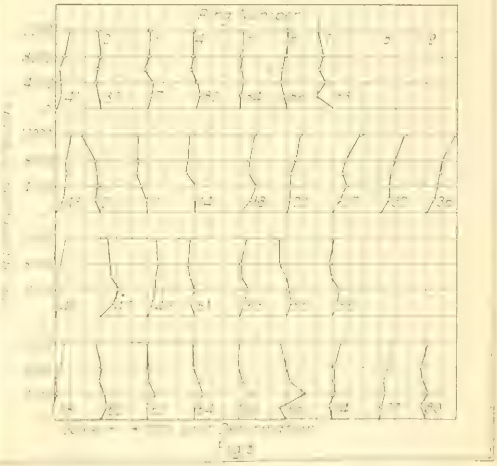


Fig. 6—Distribution of Circumferential Unit Deformations in Reinforcement for Various Loads. Fig. 7—Load Deformation Diagrams for Circumferential Gauge Lines on Concrete. Fig. 8—Load-Deformation Diagrams for Radial Gauge Lines on Concrete.

that the compression in the radial direction due to the impact was practically in line with the axis of the tile.

The deflections at the center of the dome due to the blows are shown in Fig. 11. It should be recognized that the observations were taken instantaneously and may be somewhat crude, but it is believed that they represent roughly the amount of deflection.

The above described test showed an unexpected resistance to impact. To determine whether the resistance to impact would be less if the blows were applied eccentrically, the derrick was moved to a point 3 ft. south of the center and a similar test was made. In this instance the height of the drop was uniformly 6 ft. 8 in. and no board was placed on the cinder concrete. The 12th blow caused a hole somewhat larger than the one caused at the center, but still not large enough to let the stone fall through. The form of the fracture was about as shown in Fig. 12 in cross-section. It would seem that the occurrence of the crack at a Fig. 12 indicates that the lateral thrust was well distributed even in the case of eccentrically applied impact loads.

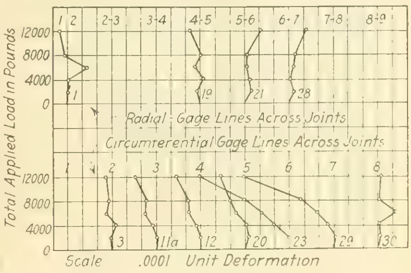


Fig 9

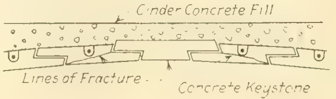


Fig.10

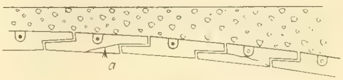


Fig 12

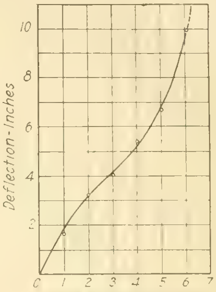


Fig 11

Fig. 9—Load-Deformation Diagrams for Radial and Circumferential Gauge Lines Across Mortar Joints.

Fig. 11—Deflection at Center Under Impact. Fig. 12—Form of Fracture Due to Impact Three Feet from Center.

The stability of the structure as a whole did not seem to be impaired by the tests previously described and the derrick was then moved to a point near the north end of the slab and an excavation made through the cinder concrete deep enough to expose the upper surface of the tiles. This area was approximately a rectangle 14 in. by 34 in. The 195-lb. stone was dropped a distance of 7 ft. 1 in. upon the unprotected dome. The first blow cracked the dome, but made no hole. One more blow from a height of 7 ft. 1 in. was applied at this point. This made a small hole, but the stone did not fall through. The derrick was then moved to a point about 1½ ft. south of the center, that is, to a point about half way between the first two points of application. Here the stone was raised to a height of 6 ft. 8 in. and dropped upon the cinder fill, which was 2¼ in. thick at this point. At the 7th blow a hole was made and the stone fell through, but did not take out all the material between holes marked 2 and 5.

In wrecking the structure the central portion of the shell was broken out from end to end. At that time there was still sufficient strength to support the weight of two men jumping upon the shell on one side of the center. This fact is mentioned merely as indicating the considerable degree of toughness in the structure.

In all the tests previously described the failures were entirely local in nature and the thing that had been feared, that due to the absence of radial reinforcement a fracture at one point might drag down the entire ring and all that portion of the structure within the ring, was not realized.

TABLE I. DATA OF IMPACT TEST NO. 1.

[illegible]	Height [illegible]	Deflection in inches.	Remarks
	4 ft. 0 in.	.16+	
	6 ft. 6 in.	[illegible]	
	6 ft. 8 in.	1	
			[illegible] radial cracks [illegible] center and [illegible] keystone chipped
	[illegible] 8 in.		[illegible] keystone broken off
		1.0	[illegible] diagonal tension starting about [illegible] ft. from center
	[illegible] 8 in		Punched small hole in center.

The method of measuring the outward deflection of the side walls was crude and the deflection probably could not be read with certainty with an error of less than ±.01 in. The observed deflection on one side at the 8,000 lb. (67 lb. per sq. in.) load was 0.02 in. No deflection of the end walls could be detected. Readings of deflection of walls were not recorded at higher loads. With this allowance for error the maximum deflection becomes .03 in. In order to find out how much lateral thrust was required to produce this lateral deflection of the walls a test was made after the dome had been wrecked and removed from the supporting walls. In this test a horizontal load was applied at the middle of the side walls close to the top of the wall. The outward deflection due to the known horizontal load was measured and has been plotted in Fig. 13. In the static test of the dome whatever horizontal thrust came upon the walls was not applied at a single point, as in the test under consideration, but was distributed along the length of the wall. Consequently the load required to cause a given deflection of the wall would be greater for the static test of the dome than for the test of the wall in which the load was applied at a single point at the center of the length of the wall. If the deflection due to the concentrated load were twice as great as the former, the horizontal thrust due to the vertical load of 8,000 lb. on the dome would be not more than 100 lb., as indicated by Fig. 13. This, of course, is negligible. There is no indication that for the higher loads the lateral deflections of the walls increased more rapidly than the load increased. It seems certain that the resistance afforded by the walls to horizontal thrusts was negligible.

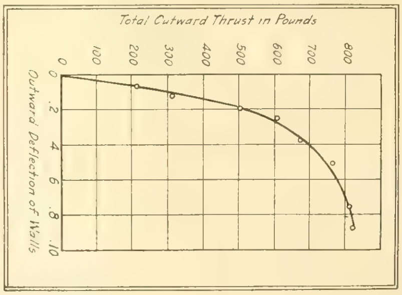


Fig. 13—Horizontal Deflection of Walls Under Known Horizontal Load.

The test of the walls by application of horizontal load indicates that even if the action of the dome required considerable elongation of the spans there was not sufficient stability to the walls to resist this increase in the span length. On the other hand the small deflection of the non-resistant supporting wall under the action of the vertical load upon the dome indicates that even if supporting walls of such a structure are capable of resisting considerable horizontal thrusts only a very small amount of horizontal deflection (or lateral movement of the support) is necessary to relieve the thrust to be resisted, and to relieve the walls of the necessity of carrying the thrust.

In a general way, the test has afforded data from which it is believed the action of such a structure may be predicted to a certain extent. The test has indicated that a structure built after the manner of the dome tested is feasible and exhibits considerable toughness. For cases in which a large unobstructed space with a domical ceiling capable of carrying a load on the floor above is desired, it seems that there are possibilities in such construction as that described. In any contemplated use of such a structure it is obvious that a circular plan would be more advantageous than a square plan, and that a square plan would be more advantageous than a rectangular plan.

REVISED SPECIFICATIONS FOR MILL CONSTRUCTION.

A new standard for the mill construction type of buildings was recommended by the National Fire Protection Association Committee on Uses of Wood in Building Construction in its report submitted May 8 at the annual convention of the association. The new features in the revised specifications deal mainly with the question of decay of wood and how to avoid same and with the strength of timber and how to calculate it. The report has not yet been finally approved by the association and so is not to be interpreted as its standard at the present time. Some of the suggested requirements regarding the use of timber follow:

Floors.—(a) The floors shall have the least possible amount of openings, and these shall be protected in an approved manner.

(b) The floors shall be not less than 3 in. (nominal) splined or tongued and grooved, plank covered with 1-in. (nominal) flooring laid crossways or diagonally. Top flooring shall not extend closer than ½-in. to walls to allow for swelling in case the floor becomes wet. This space shall be covered by a moulding so arranged that it will not obstruct movements of the flooring.

Note.—Corbelling of brickwork under floor planks is recommended to take place of the above mentioned moulding.

(c) If laminated floors are used, at least two laminations at the wall shall be omitted until after glazing and roofing have been completed.

(d) Two thicknesses of water-proof paper or felt with sealing compound (but no asbestos) shall be laid between planking and the top flooring, and shall be turned up at least 3 in. around the posts and at the sidewalls. A counter-flashing of galvanized iron or a baseboard nailed in place with the joint between it and the floor covered with a moulding shall protect the upper ends of the water-proofing.

A fairly smooth surface shall be provided before any water-proofing is laid, and the felt or paper shall be laid breaking joints and mopped with a water-proof sealing compound. The top flooring shall be laid immediately following the final mopping.

Note.—It is recommended that the floors shall have a pitch about 1 in. in 20 ft. to scuppers provided at the floor level, number and spacing to meet the approved requirements.

(e) Where plank floors are laid flat the boards shall be two bays in length if possible laid to break joints every four feet.

(f) Laminated floors consisting of planks 6 in. to 8 in. wide set on edge close together and spiked at about 18 in. distance with 60 penny nails shall have the joints broken in such a manner that no continuous line will occur across the floor and shall not be spiked to the supporting girders in order to avoid a movement in the girders at the walls due to expansion which may be caused by dampness. The joints between the planks of a laminated floor shall be perfectly tight.

(g) All girders or floor beams shall preferably be single stick timbers, but if double stick timbers are used, they shall be properly bolted together and contact faces shall be treated to prevent decay.

(h) Floor timbers shall not be less than 6 in. (nominal) in either dimension.

Note.—In the determination of the dimensions of floor beams special attention shall be paid not only to actual loads to be superimposed, but also to the factor of impact or vibration of machinery.

(i) In the calculation of the strength of beams and columns, the permissible stresses established in the following table shall be used and the net cross section of timbers and not the nominal section shall be considered.

WORKING UNIT STRESSES FOR STRUCTURAL TIMBERS USED IN DRY LOCATIONS.

	Bending		Compression	
Species of timber.	Stress in extreme fiber. Lb. sq. in.	Horizontal shear stress. Lb. sq. in.	Parallel to grain, short columns. Lb. sq. in.	Perpendicular to grain. Lb. sq. in.
Fir, Douglas—				
Dense grade	1,600	100	1,200	350
Sound grade	1,300	85	900	300
Hemlock, eastern	1,000	70	700	300
Hemlock, western	1,300	75	900	300
Oak	1,400	125	900	400
Pine, eastern white	900	80	700	250
Pine, Norway	1,100	85	800	300
Pine, southern yellow—				
Dense grade	1,600	125	1,200	350
Sound grade	1,300	85	900	300
Spruce	900	70	600	200
Tamarack	1,200	95	900	350

Note.—The safe working stresses given in this table are for timbers with defects limited according to the sections on defects in the rules of the Southern Pine Association for select structural material. "Dense" southern yellow pine and "dense" Douglas fir should also conform to the other requirements of this rule. "Sound" southern yellow pine and "sound" Douglas fir require no additional qualifications, whereas the other species should, in addition to being graded for defects, have all pieces of exceptionally low density for the species excluded.

(j) Wall plates or boxes of sufficient area and of an approved self-releasing type shall be provided at the ends of floor beams where they rest on walls.

(k) Where girders meet at the columns they should be fitted around them or butted up close to them. The ends of beams shall be held in place by steel or iron straps spiked, bolted or lag screwed on their sides unless the post caps have sides projecting upwards which can be lag screwed to the beams.

(l) Where intermediate beams are found necessary for the support of a floor they shall rest on top of the girders. Where steel or iron hangers are absolutely necessary the ends of beams shall be fitted in as well as possible and any interstices between beams framed together shall be filled in with a preservative compound.

(m) The width of floor bays depends on the layout of the floor, the loads to be carried and the arrangement of the sprinklers; it shall be not less than 6 ft. between the centers of the beams.

(n) All exposed woodwork shall be planed smooth.

(o) Pipes or tight-fitting conduits extending through floor shall be provided with metal thimbles and shall be made watertight to a height of 3 in. above floor.

(p) Cellar floor should be of cement or tar concrete laid on a suitable foundation of cinders or broken stone. The cement concrete shall be properly water or damp-proofed as the conditions may require.

Note.—Creosoted wood blocks, embedded in pitch or asphalt, may be used as finish flooring over concrete. Planking 3 in. thick embedded in tar concrete and having a top or wearing flooring over it may also be used where required.

Posts.—(a) Posts shall be proportioned in size according to the loads they will carry, but their cross-sectional dimensions shall not be less than 8 in. All corners to be rounded or champfered. In the calculation of the strength of posts the net cross section shall be considered.

(b) They shall be superimposed throughout all stories on metal post caps with brackets or shall have ends connected by properly designed steel or iron caps, pintle and base plate. Wood bolsters may be used to support roof girders only.

(c) Posts shall never rest directly on floor timbers.

Quality and Kind of Timber.—(a) The structural timber used shall be free from any form of decay. Sap stain, where the timber is otherwise sound, shall not be considered a defect.

(b) For any defects in limited number or size a corresponding decrease shall be made for the allowable stresses used for the calculation of the strength of timber.

(c) Rough sawed timber shall not be more than ¼-in. and dressed timber not more than ½-in. scant the nominal size.

Note.—The following specifications for timber are given herewith for general information and are recommended as good practice.

Quality.—Girders or beams and posts, when made of southern yellow pine or Douglas fir, shall conform in quality to the specifications for "Dense Grade Pine," adopted by the American Society for Testing Materials (A. S. T. M. Standards 1916; serial designation D 10 to 15; paragraph, General Requirements; pages 515 and 516) and by the American Railway Engineering Association (Bulletin 189; September, 1916; page 78); and girders or beams and posts of oak shall conform to the requirements of oak timbers adopted by the American Railway Engineering Association (Manual of Recommended Practice, 1915, pages 641 and 642); all definitions in the specification referring to oak timbers to refer to standard definitions in this same manual pages 631 to 640 inclusive.

Grade.—Girders or beams of southern yellow pine or Douglas fir shall show not less than 85 per cent of heartwood on each of the four sides measured across the sides anywhere in the length of the piece. In Volume 1 shall not have sound knots greater in diameter than one-fourth the width of the face on which they appear—maximum knot 1½ in. Shall not have in Volume 2 sound knots greater in diameter than one-half—the width of the face on which they appear—maximum knot 3 in.

The aggregate diameter of all knots within the center half of the length of any face shall not exceed the width of that face.

The diameter of a knot on the narrow or horizontal face of a beam is to be taken as its projection on a line perpendicular to the edge of the timber. On the wide or vertical face, the smallest dimension of a knot is to be taken as its diameter.

Round or ring shakes shall not occupy, at either end of the material, more than one-fourth the width of green material, nor more than one-third the width of seasoned material.

Any combination of checks or shakes which would reduce the strength to a greater extent than the allowable round shakes will not be permitted. Shakes shall not show on the faces of either green or seasoned timber.

Shall not have diagonal grain with slope greater than one in twenty in Volume 1.

Posts or columns shall not have sound knots greater in diameter than one-third the least width of the column—maximum knot 4 in Shall show at least 85 per cent of heart on each of the four sides measured across the sides anywhere in the length of the piece.

Floor Planking.—Floor planking of southern yellow pine or Douglas fir shall conform to the grade "Merchantable" as defined by the timber rules of the Southern Pine Association, Jan. 1, 1917.

For buildings where high humidity is maintained, all floor planks should conform to the grade "Merchantable," but they should be all heart, no sap should be permitted.

Durability.—(a) The decay of wood is caused by vegetable growths called fungi, which thrive in wood in damp, poorly ventilated locations. The prevention of decay in mill buildings can be accomplished by the elimination of excessive moisture, which may be brought about by thorough ventilation or heating of all portions. Special care should be given to the design, rot proofing and selection of lumber to be used under moist conditions.

(b) Dry lumber should be used wherever possible, and should be well protected from the weather after delivery at the site. The use of green or partially dried lumber, or lumber wet by rain, snow or other causes, may create conditions favorable to rapid decay. This is particularly true of lumber in large beams or that to be used in laminated floors, under which conditions it will dry out slowly.

(c) Girders or beams which rest in masonry walls shall not be sealed in; air space of at least 1½ in. shall be provided all around the end to allow proper ventilation.

(d) Two brush coats of hot coal tar creosote or other suitable preservative applied to the ends of thoroughly dried timbers will assist materially in preventing decay if conditions are not too moist.

Note.—Do not rely upon brush treatment where timbers are to be used in damp or moist locations.

(e) Ends of girders or beams when resting on metal plates shall have the bearing surface protected by a piece of creosoted saturated felt or paper.

(f) Creosote or other preservative compound shall be applied also to the ends of columns between floors.

(g) The timbers for a mill constructed building shall be protected from moisture during construction and no paint or finish of any kind shall be applied to it before it is dry, preferably one year after the building is completed.

(h) In very exceptional cases, the antiseptic treatment of the entire structure may be desirable. This should not be done without consulting with a competent expert in the treatment of wood.

(i) Care should be taken if plaster is applied to timbers which are to be used in a dry location to have the timber thoroughly dry before its application. In cases in which such coated timbers are to be used in a moist location, it is desirable to use timber that has been thoroughly impregnated with a satisfactory wood preservative.

(j) The plaster shall be porous to permit circulation of air.

The Committee on Uses of Wood in Building Construction consisted of the following: Julius Franke, Chairman; John S. Bates, Alexander Brociner, Frank D. Chase, John Foley, F. J. Hoxie, Charles E. Paul, G. J. Ray, Willis O. Robb, Clyde H. Teesdale, Hermann von Schrenk, Ira H. Woolson.

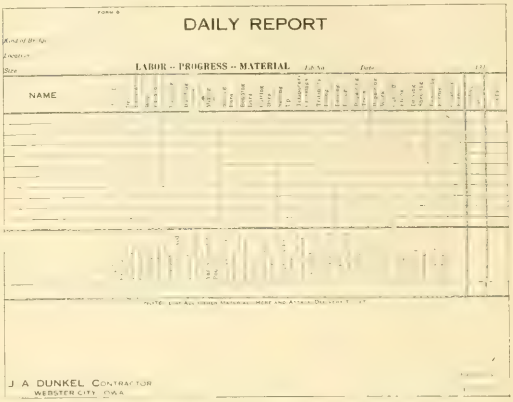
A preliminary experiment was made recently at the U. S. Forest Products Laboratory to show the effect of steaming upon bleeding of creosote. The wood came from the cylinder quite clean and dry, and did not bleed two weeks standing in the laboratory. This indicates that the final steam bath may be valuable in the treatment of such material as silo staves, crossarms, elevated railway ties, pipe staves, etc., where bleeding of the oil is objectionable. Before drawing definite conclusions, however, more work must be done.

Bids were opened recently by the Quartermaster General's Office for the supply of motor trucks. Specifications showed the Government tentatively in the market for as many as 35,000 trucks, the number required for transport purposes for an army of 2,000,000 men. It is estimated that there are not more than 40,000 motor trucks on the entire western battle front in Europe. An order for 35,000 trucks by the American Government would result in putting the United States on a par with all of the belligerents in this respect.

COST-KEEPING SYSTEM FOR SMALL BRIDGE AND CULVERT JOBS.

A cost-keeping system particularly well adapted to the small and scattered culvert and bridge jobs encountered in county work in Iowa is employed by J. A. Dunkel, Contractor, Webster City, Ia.

The foreman makes a daily report on labor, progress and materials, the blank shown in Fig. 1 being used for this purpose. This report shows the labor hours distributed to all the kinds of work done, all materials received and used, and empty sacks returned. The report gives a good check each day on all items, and permits the making of a comparison of the cost of each on different jobs. The foremen on the different jobs are furnished the labor costs for all jobs each month and they knowing what the other men are doing they are supplied with an incentive to reduce their own costs when possible.



FORM 6

DAILY REPORT

Kind of Bridge
Location
Size

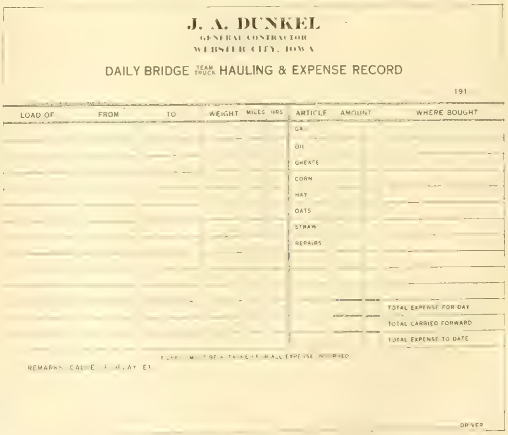
LABOR -- PROGRESS -- MATERIAL Job No. Date 191

NAME

J A DUNKEL Contractor
WEBSTER CITY IOWA

Fig. 1—Form for Foreman's Daily Labor, Progress and Material Report (Actual Size of Blank 7¾x9¾ in.)

Bills for materials and supplies, also duplicates of material orders are attached to each daily report. As the jobs are small Mr. Dunkel finds that it works very satisfactorily for teamsters and truck drivers to make their own reports. They keep an account of all expenses and attach bills for all items to their report. The blank used for this purpose is illustrated as Fig. 2.



J. A. DUNKEL
GENERAL CONTRACTOR
WEBSTER CITY, IOWA

DAILY BRIDGE TEAM/TRUCK HAULING & EXPENSE RECORD

191

LOAD OF	FROM	TO	WEIGHT	MILES HRS	ARTICLE	AMOUNT	WHERE BOUGHT
					GAS		
					OIL		
					GREASE		
					CORN		
					HAY		
					OATS		
					STRAW		
					REPAIRS		

TOTAL EXPENSE FOR DAY
TOTAL CARRIED FORWARD
TOTAL EXPENSE TO DATE

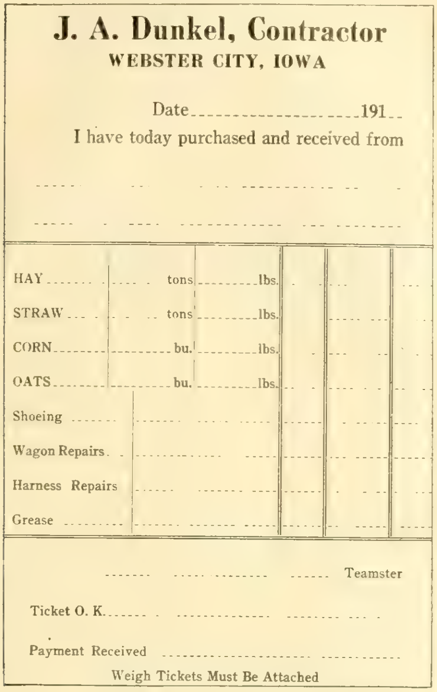
REMARKS CAUSE OF DELAY ETC

DRIVER

Fig. 2—Daily Hauling and Expense Record. (Actual Size, 7¼x8½ in.)

The form employed for purchases is shown as Fig. 3. Previous to the use of this ticket it was found that many small items of feed, etc., were not turned in at the time the purchase was made. This caused trouble as bills sometimes turned up months afterward. Under the present system when anything is purchased a copy of the ticket is given as a receipt and another copy is attached to the teamster's report. The use of this ticket makes considerable saving each month in the purchases.

As the work is in the country with sometimes five moves per month, Mr. Dunkel uses wagon camps, one for cooking and dining room and one for sleeping quarters. The men are paid on the hourly basis with deductions for meals. The boarding account is kept separate and is checked up each month so that the contractor knows exactly how he stands.



J. A. Dunkel, Contractor
WEBSTER CITY, IOWA

Date.......................191..

I have today purchased and received from

HAY	tons	lbs.	
STRAW	tons	lbs.	
CORN	bu.	lbs.	
OATS	bu.	lbs.	
Shoeing			
Wagon Repairs			
Harness Repairs			
Grease			

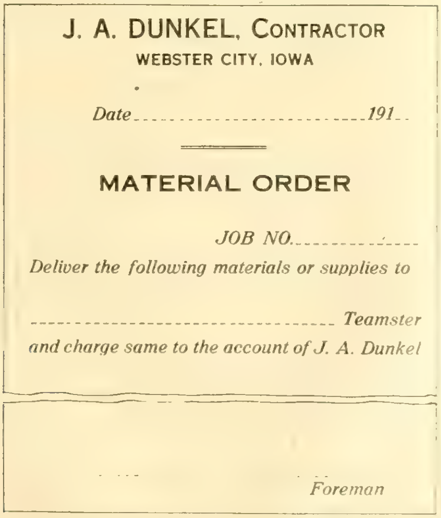
.... Teamster

Ticket O. K. ....

Payment Received ....

Weigh Tickets Must Be Attached

Fig. 3—Purchase Ticket. (Actual Size, 5¾x3½ in.)



J. A. DUNKEL, CONTRACTOR
WEBSTER CITY, IOWA

Date..........................191..

MATERIAL ORDER

JOB NO..............

Deliver the following materials or supplies to

.... Teamster

and charge same to the account of J. A. Dunkel

Foreman

Fig. 4—Material Order. (Actual Size, 8x3 in.)

George W. Fuller Co., New York City, has been awarded contract for constructing the national army cantonment at Fort Riley, Kan.

DISTRIBUTION OF PRESSURES THROUGH EARTH FILLS.

An investigation to obtain data on the distribution of vertical pressures through earth fills under concentrated loads has been conducted under the direction of Mr. A. T. Goldbeck of his U. S. Office of Public Roads. Sand fills were investigated up to a depth of 5 ft. and the pressures under them measured with a special diaphragm cell. The results of his investigation are described by Mr. Goldbeck in a paper presented on June 26 at the 26th annual meeting of the American Society for Testing Material. The following notes are taken from this paper:

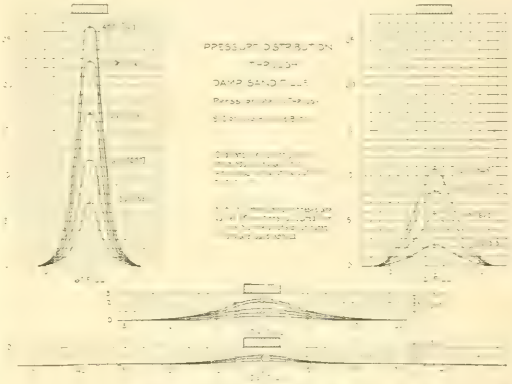


Fig. 1—Results of Readings for Pressure Applied Through 3-In. Circular Bearing Block.

The results of the pressure readings are shown in Figs. 1, 2 and 3. The readings due to the weight of sand alone were subtracted from the readings obtained when the fill was loaded. The differences were plotted as ordinates. The abscissas represent the lateral distribution of the pressures. Since a circular bearing block was used, it is to be assumed that the pressures in all lines passing through the center are identical with those measured. The volume of the solid generated by rotating a curve of pressure about its vertical axis, when multiplied by the number of pounds represented by a cubic inch, will equal the reaction. These reactions have been calculated for a number of the applied loads, and are

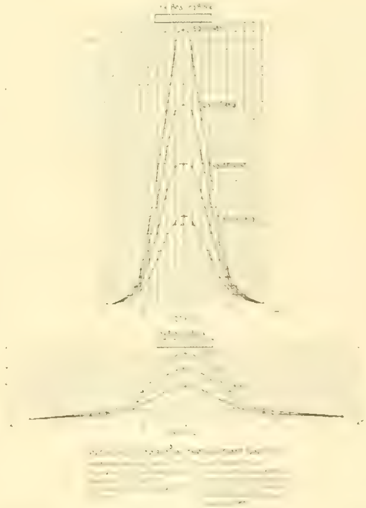


Fig. 2—Results of Readings for Pressure Applied Through 13½-In. Circular Bearing Block.

shown in parentheses on the curves. The loads applied are shown outside of the parentheses; theoretically they should be identical, and actually they are nearly equal. When it is remembered that any slight difference in the compaction of the sand in the different radial planes will change the intensity of the pressure exerted in those planes, and when it is remembered that the pressures were measured principally in a single plane and partly in a plane at right angles, the agreement of the calculated reactions with the applied loads is remarkably close. The reliability of the apparatus for measuring pressures through sand is thus established.

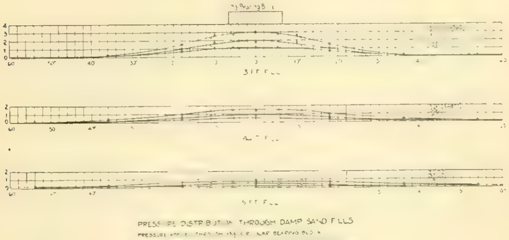


Fig. 3—Results of Readings for Pressure Applied Through 13½-In. Circular Bearing Block for 3-Ft., 4-Ft. and 5-Ft. Fills.

Application of Results.

The designing engineer is continually encountering the design of structures subjected to the pressure of earth fills or to pressures transmitted through fills. The present tests were made under conditions which resemble those in a road slab having an earth covering. In the design of such a slab, the engineer is primarily interested in the amount of distribution of a concentrated load furnished by the earth fill. He would like to know the lateral distribution in order that he might figure what width of slab carries the load. He would like to know the distribution forward or backward from the wheel load in order that he might determine the moment about the concentrated load of the distributed pressure load, and thence obtain the bending moment.

It is very common practice at the present time to assume that a wheel load acts over a definite area on top of the fill, that the pressure is transmitted with uniform intensity to the slab, and that it acts over an area determined by an assumed angle of spread from the top of the fill. This assumption of uniform intensity is of course wrong as shown by these pressure measurements, but forms a convenient means of calculation provided the correct intensity and area of pressure are assumed. In order to make use of the curves of pressure for practical calculations of bending moment, it would be well to know the location of the center of gravity of the half volume of the figure generated by revolving the curve about its central axis. The distance from the center of gravity to the center of the curve, multiplied by one-half the total load, is the moment about the wheel load of the distributed pressure to either side of that load. The centers of gravity of these half volumes for the maximum loads applied to the various depth of fill have been calculated, and are shown in Table I.

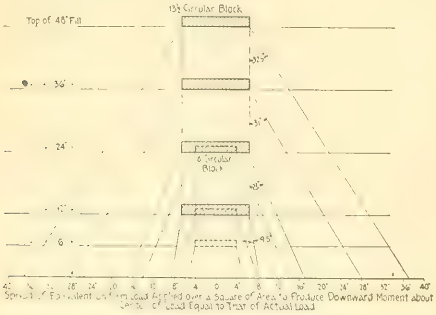


Fig. 4—Equivalent Squares of Area.

TABLE I.—LOCATION OF CENTER OF GRAVITY OF HALF OF PRESSURE ON SLAB WITH RESPECT TO CENTER OF LOAD.

	8-in block		13½-in block	
Depth of fill, in.	Load, lb.	Center of gravity to center of load, in.	Load, lb.	Center of gravity to center of load, in.
6	1,400	2.6	.....	....
12	1,200	3.6	1,800 5,000	4.4 4.2
24	1,400	7.0	1,800 4,000	10.5 8.4
36	1,400	16.8	1,800 5,000	16.0 14.0
48	.....	....	5,000	18.5

If for the convenience of the designer, the pressure at the bottom of the fill is considered uniform and acts over a square area, the sides of each of these areas will be equal to the values in the last column of the preceding table multiplied by four. The sides of the squares of areas thus obtained are somewhat different for the highest and lowest loads applied and may be tabulated as in Table II.

TABLE II.—EQUIVALENT SQUARES OF AREA.

		Length of side of square of uniform pressure area, in.		
Depth of fill, in.	Load on 8-in block, lb.	8-in. block.	13½-in. block.	Load on 13½-in. block, lb.
6	1,400	10.4	....	.....
12	1,200	14.4	17.6 16.8	1,800 5,000
24	1,400	28.0	42.0 33.6	1,800 4,000
36	1,400	67.2	64.0 56.0	1,800 5,000
48		....	74.0	5,000
60		....	....	.....

The results in Table II, for the high loads only, are shown graphically in Fig. 4. In calculating the bending moment in a slab, the designer, instead of using the varying intensity of the load, as it is shown to exist in the pressure measurements, may consider the same total pressure applied over a square of area whose side is given in Table II or as shown in Fig. 8.

It is realized that in order to give complete data on this problem, so that it will be entirely useful to the designing engineer, several other kinds of filling material should be investigated, and bearing blocks shaped and spaced like wheels and rollers should also be applied to the fill. This will all be undertaken in the investigation still under way, as well as the question of lateral pressures produced by vertical loads.

INDUSTRIAL NOTES.

In order to obtain space for a larger stock of Standard mixers and contractors' equipment the Standard Scale & Supply Co. has removed its Chicago office to North May street, between Lake and Randolph streets.

Large contracts for corrugated metal culverts for use on the state highways of Kentucky have recently been let to The Canton Culvert & Silo Co. of Canton, O., by the counties of Clinton, Bourbon, Madison, Jessamine and Greenup.

The Concrete Mixing & Placing Co., 123 West Madison St., Chicago, has been awarded judgment by the Circuit Court of Missouri in its suit against the McMahon Construction Co. The McMahon Construction Co. had bought and used a machine which the plaintiffs claimed was an infringement on the one controlled by it. The judgment was for damages for failure to use the machine of the Concrete Mixing & Placing Co.

F. C. Wilcox and H. B. Franklin, well known to contractors in the central west through their association with the Foote Concrete Machinery Co., have organized a new company under the name of Wilcox, Franklin & Co., with headquarters at 1324 S. Michigan avenue, Chicago, to handle Sterling motor trucks and Troy trailers in the state of Illinois and portions of Indiana and Iowa. C. C. Dawson, formerly Omaha representative for Foote mixers, will be sales manager of the new company. Mr. Franklin will continue as manager of the Chicago office of the Foote Concrete Machinery Co., while Mr. Wilcox will give his time to the affairs of the new organization.

Announcement has been made of the consolidation of the Blaw Steel Construction Co. and the Knox Pressed & Welded Steel Co., effective July 1, 1917. The name of the new company will be Blaw-Knox Co., with executive offices at Hoboken, Allegheny County, Pa.; general offices in the Farmers' Bank building, Pittsburgh, Pa.; branch offices at New York, Chicago, Boston and San Francisco, and works at Hoboken and Wheatland, Pa. The personnel of the two organizations will remain unchanged. The merger of the two companies will give each company increased facilities and will permit of even higher standard of service than has been the custom before. The Blaw Steel Construction Co. has been engaged in the manufacture of the well known Blaw steel form for concrete work, Blaw clam shell buckets and general structural steel fabrication. The same organization which has handled this work will continue to do so. The Knox Pressed & Welded Steel Co., whose plant is located at Wheatland, is engaged in the manufacture of water cooling devices for open hearth furnaces, also of heavy hydraulic pressed steel plate work. Again, the same organization which has handled the Knox business will continue to do so.

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